



**US Army Corps  
of Engineers**

Hydrologic Engineering Center

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# **Reservoir Management Decision Support System for the Connecticut River Watershed**

## **Appendix A: Modeled Reservoirs for the Connecticut River Watershed Application of HEC-ResSim**

**August 2013**

<b>REPORT DOCUMENTATION PAGE</b>			Form Approved OMB No. 0704-0188		
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1. REPORT DATE (DD-MM-YYYY) August 2013		2. REPORT TYPE Project Report		3. DATES COVERED (From - To)	
4. TITLE AND SUBTITLE Reservoir Management Decision Support System for the Connecticut River Watershed  Appendix A: Reservoir Management Decision Support System for the Connecticut River Watershed			5a. CONTRACT NUMBER		
			5b. GRANT NUMBER		
			5c. PROGRAM ELEMENT NUMBER		
6. AUTHOR(S) David Julian, Woodrow Fields, Leila Ostadrahimi, John Hickey, Townshend Barker, Chris Hatfield			5d. PROJECT NUMBER		
			5e. TASK NUMBER		
			5f. WORK UNIT NUMBER		
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) U.S. Army Corps of Engineers Institute for Water Resources Hydrologic Engineering Center (CEIWR-HEC) 609 Second Street Davis, CA 95616-4687				8. PERFORMING ORGANIZATION REPORT NUMBER PR-88b	
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES) U.S. Army Corps of Engineers New England District 696 Virginia Road Concord, MA 01742				10. SPONSOR/ MONITOR'S ACRONYM(S)	
				11. SPONSOR/ MONITOR'S REPORT NUMBER(S)	
12. DISTRIBUTION / AVAILABILITY STATEMENT Distribution authorized to U.S. Government Agencies only.					
13. SUPPLEMENTARY NOTES					
14. ABSTRACT This report was developed by the US Army Corps of Engineers Hydrologic Engineering Center (CEIWR-HEC) with New England District (CENAE) for assisting in the development of a Decision Support System for the Connecticut River watershed. The Decision Support System uses HEC-ResSim, HEC-EFM, HEC-RAS and estimates of unimpaired stream flows prepared by the U.S. Geological Survey. The Decision Support System will be used to analyze reservoir operating scenarios for a variety of water management purposes, including environmental, hydropower, flood control, water supply, and recreational considerations. This appendix provides detailed information about the modeled reservoirs. The overall Decision Support System is documented in PR-88.					
15. SUBJECT TERMS Hydrology, Decision Support System, HEC-ResSim, watershed, river, Connecticut River, water management, streamflow, Reservoir System Simulation, model, reservoir operation, operation set, data					
16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT UU	18. NUMBER OF PAGES 629	19a. NAME OF RESPONSIBLE PERSON
a. REPORT U	b. ABSTRACT U	c. THIS PAGE U			19b. TELEPHONE NUMBER

# **Appendix A: Modeled Reservoirs for the Connecticut River Watershed Application of HEC-ResSim**

**August 2013**

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PR-88b

Separate from the report for the Decision Support System of the Connecticut River watershed is this reservoir reference appendix document. It contains information about each reservoir modeled in the HEC-ResSim model. Information for each reservoir includes descriptions and sources of all physical and operational parameters in the model. This appendix is to serve as the reference guide in case changes to the model occur. It can also be used for setting up models at the sub-watershed and individual reservoir scale.

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# Ball Mountain

## I. Overview

Ball Mountain Dam is a dam in Jamaica, Windham County, Vermont, in the southeastern part of the state. It was constructed between 1957 and 1961 by the United States Army Corps of Engineers and is owned and operated by the Corps. It is primarily used for flood control but is also used for recreation.

Figure 1 shows the location of Ball Mountain Dam as it is represented in the HEC-ResSim model. Figure 2 shows a photo of Ball Mountain Dam.

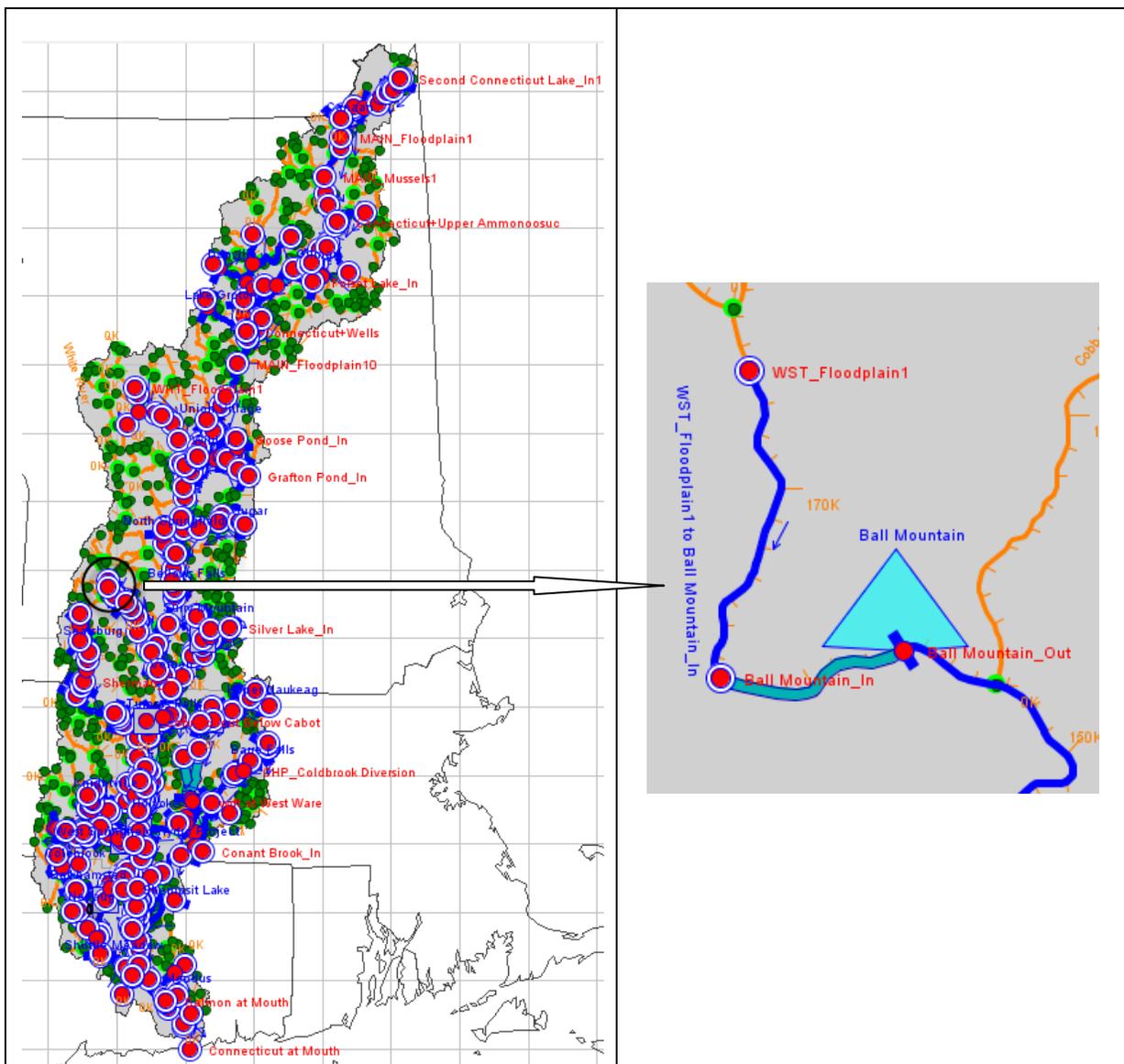


Figure 1: HEC-ResSim Map Display Showing Location of Ball Mountain dam



**Figure 2: Photo of Ball Mountain Dam**

## **II. Physical Characteristics**

The physical characteristics of the reservoir are separated between the Pool and the Dam in the HEC-ResSim model. The elevation-storage-area defines the pool as shown in Figure 3. The dam consists of two types of outlets: (1) controlled slide gates, and (2) uncontrolled outlet, as shown in Figure 4. All physical and operations data were provided by US Army Corps New England District, through both a previous ResSim model and the Reservoir Regulation Team website<sup>1</sup>.

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<sup>1</sup> [http://rsgisias.crrel.usace.army.mil/nae/cwms\\_map.map\\_index](http://rsgisias.crrel.usace.army.mil/nae/cwms_map.map_index)

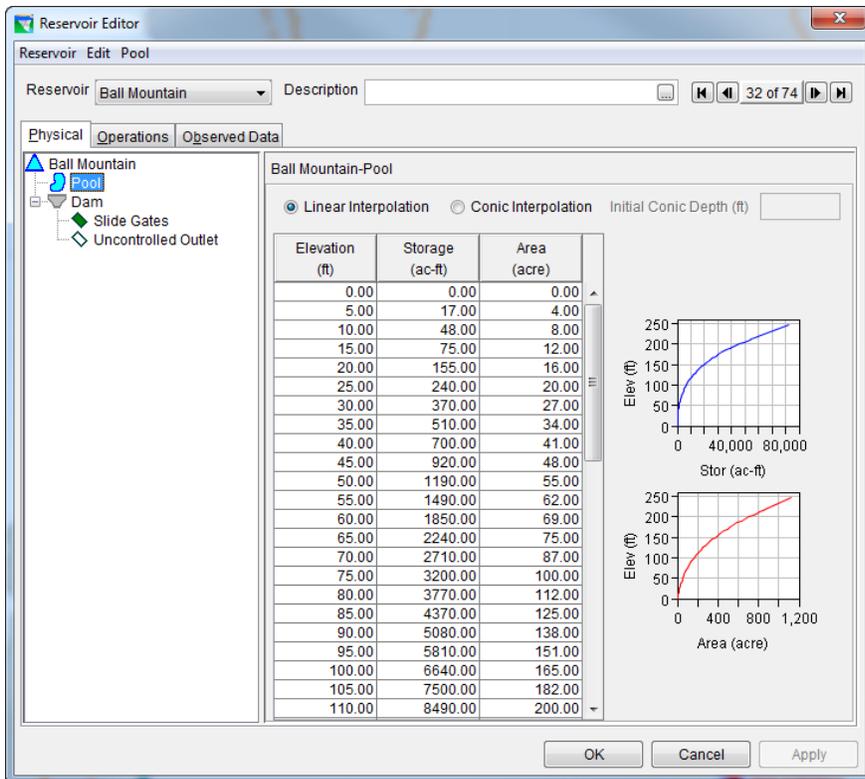


Figure 3: Reservoir Editor: Physical Tab -- Pool

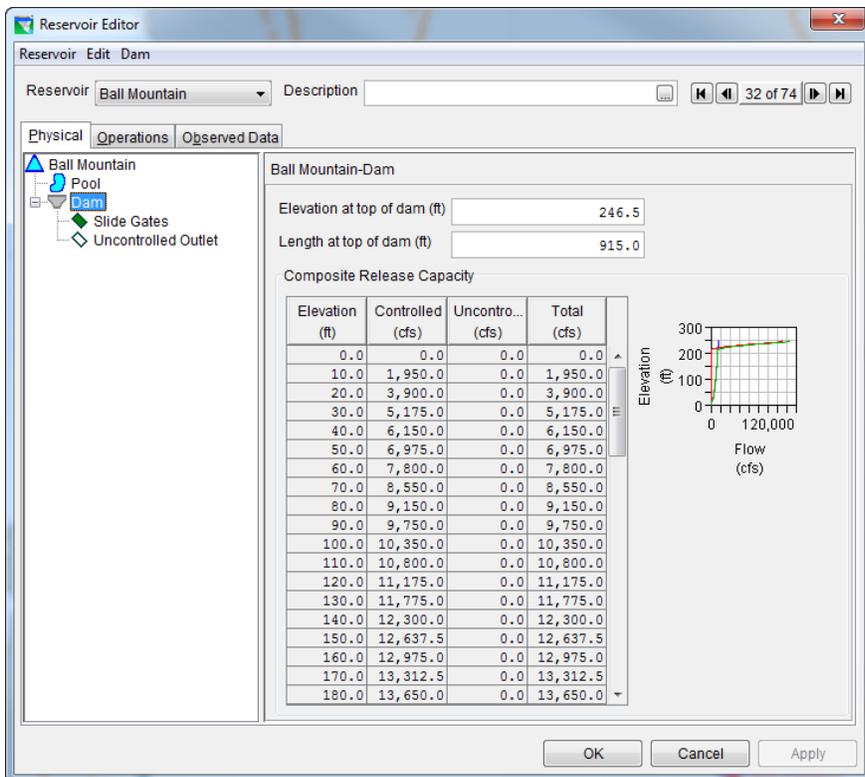


Figure 4: Reservoir Editor: Physical Tab -- Dam

### III. Operations

#### A. Operation Set

Zones are used to define the operational storage in the reservoir to determine the reservoir release through analysis of the rules contained within each zone. Figure 5 shows the definition of Ball Mountain’s “ExistingOps” operational zones, which consist of zones of Top of dam (246.5 ft), Surcharge (236.5 ft), Flood Control (211.5 ft), Conservation (25-65 ft), and Inactive zone (5 ft).

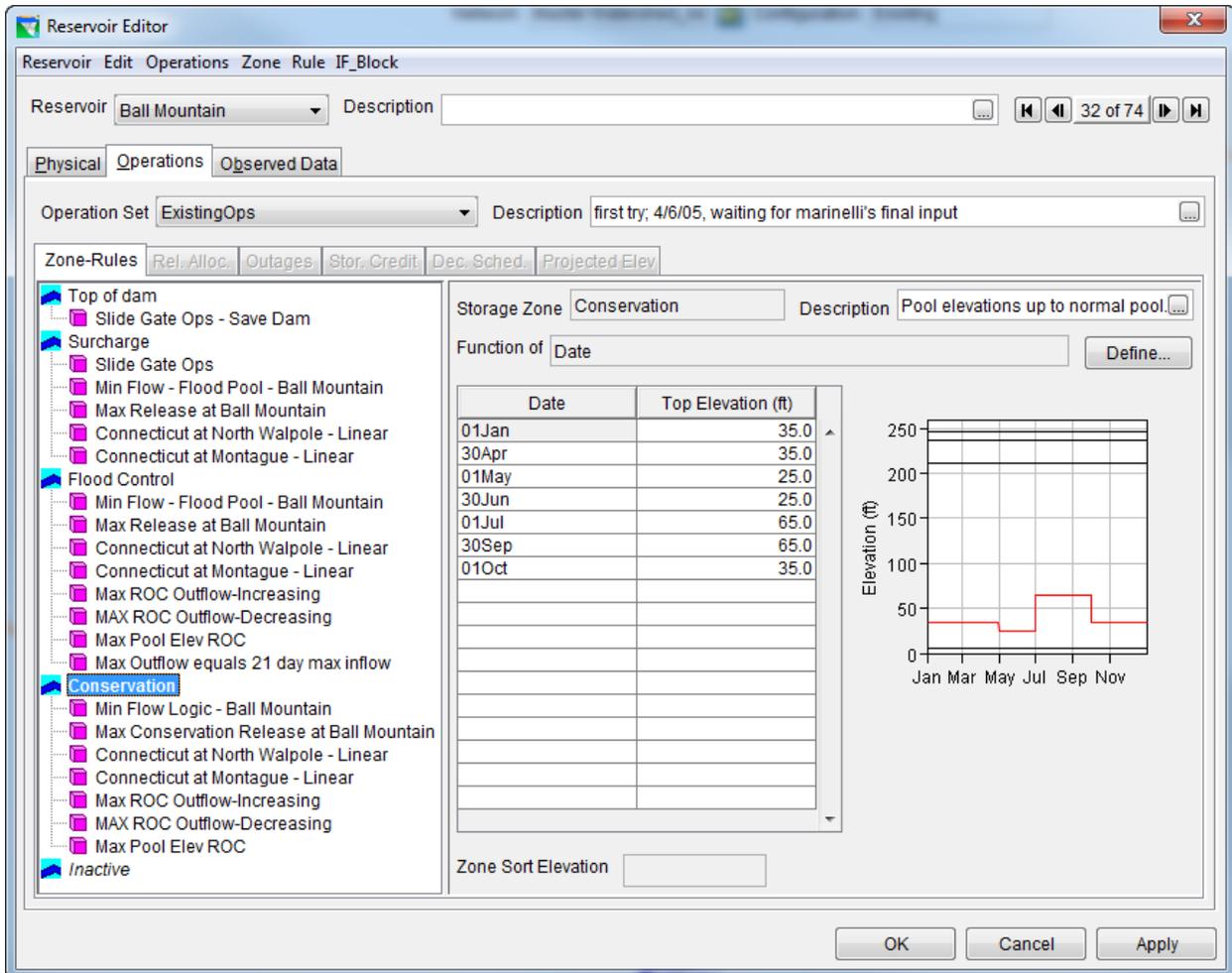


Figure 5: Reservoir Editor: Operations Tab –Existing Ops OpSet – Guide Curve

## B. Rule Illustrations

Figure 6 shows a set of operational rules specified for each zone that reflects the operation set named Existing Ops. As described in the Simulation/Verification section of the report, adjustments were made to the operations to closer match gauge data.

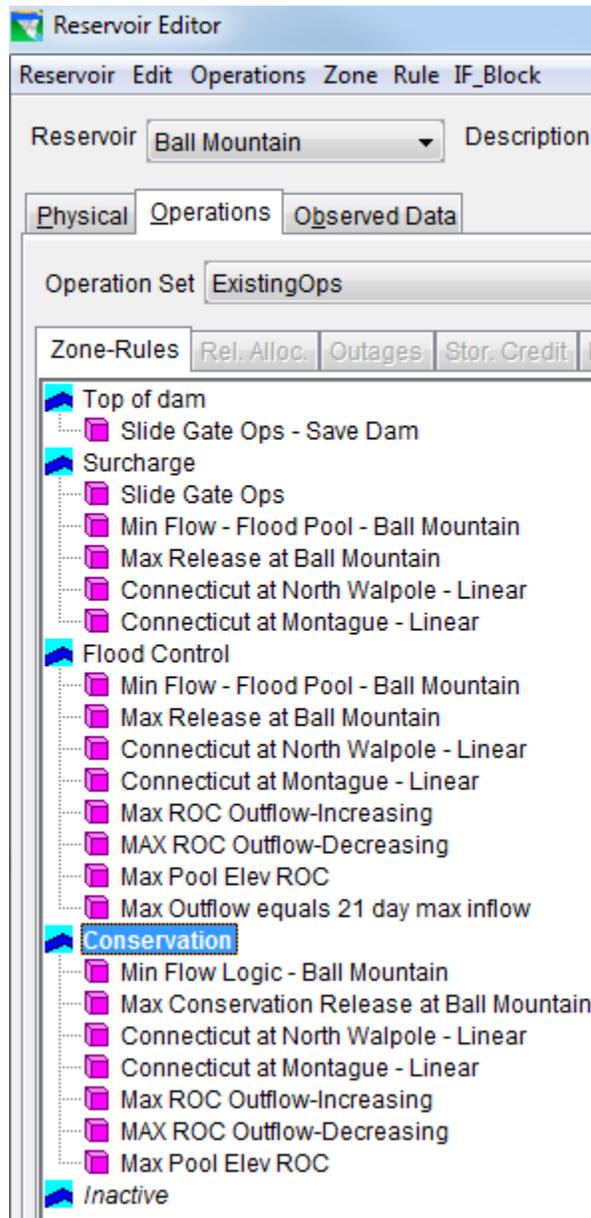


Figure 6: Reservoir Editor: Operations Tab – Existing Ops OpSet – Zones and Rules

## C. Rule Descriptions

### 1. Slide Gate Ops-Save Dam

Figure 7 shows the content of “Slide Gate Ops-Save Dam” rule. This rule represents the maximum allowable release from Slide gates when the pool is in Top of dam zone as a function of pool elevation.

The screenshot shows the 'Operations Tab' in the Reservoir Editor. The 'ExistingOps' operation set is selected, and the 'Slide Gate Ops - Save Dam' rule is highlighted in the tree view. The configuration panel for this rule is displayed, showing the following details:

- Operates Release From:** Ball Mountain-Slide Gates
- Rule Name:** Slide Gate Ops - Save Dam
- Function of:** Ball Mountain-Pool Elevation, Period Average, 0.0 hr lag, 48.0 hr period
- Limit Type:** Maximum
- Interp.:** Linear

The central table defines the release limits based on pool elevation:

Elev (ft)	Release (cfs)
236.5	0.0
238.5	1000.0
240.5	5000.0
246.5	15000.0

To the right of the table is a line graph showing the relationship between Elevation (ft) on the x-axis and Release (cfs) on the y-axis. The graph shows a linear increase in release as elevation increases, starting at 0 cfs at 236.5 ft and reaching 15,000 cfs at 246.5 ft.

Additional options on the right include:

- Period Average Limit
- Hour of Day Multiplier
- Day of Week Multiplier
- Rising/Falling Condition
- Seasonal Variation

Figure 7: Reservoir Editor: Operations Tab – Existing Ops OpSet – Slide Gate Ops-Save Dam

## 2. Slide Gate Ops

Figure 8 shows the content of “Slide Gate Ops” rule. This rule represents the maximum allowable release from Slide gates as a function of pool elevation when pool is in surcharge zone.

The screenshot shows the 'Slide Gate Ops' rule configuration in the Reservoir Editor. The main configuration panel includes the following details:

- Operates Release From:** Ball Mountain-Slide Gates
- Rule Name:** Slide Gate Ops
- Description:** first try, 4/6/05, waiting for marinelli's final input
- Function of:** buntain-Pool Elevation, Period Average, 0.0 hr lag, 48.0 hr period
- Limit Type:** Maximum
- Interp.:** Linear

The configuration includes a table of release values and a corresponding graph:

Elev (ft)	Release (cfs)
211.5	5000.0
212.0	4500.0
213.0	3000.0
214.0	1250.0
214.714	0.0
236.5	0.0
238.5	1000.0
240.5	5000.0
246.5	15000.0

The graph plots Release (cfs) on the y-axis (0 to 16,000) against Elev (ft) on the x-axis (210 to 250). The curve shows a decrease in release from 5000 cfs at 211.5 ft to 0 cfs at 214.714 ft, remains at 0 cfs until 236.5 ft, then increases to 1000 cfs at 238.5 ft, 5000 cfs at 240.5 ft, and reaches 15000 cfs at 246.5 ft.

Additional options in the configuration panel include:

- Period Average Limit
- Hour of Day Multiplier
- Day of Week Multiplier
- Rising/Falling Condition
- Seasonal Variation

Figure 8: Reservoir Editor: Operations Tab – Existing Ops OpSet – Slide Gate Ops

### 3. Min Flow-Flood Pool-Ball Mountain

Figure 9 shows the content of “Min Flow-Flood Pool-Ball Mountain” rule. This rule shows the minimum allowable release from dam during flood control operations.

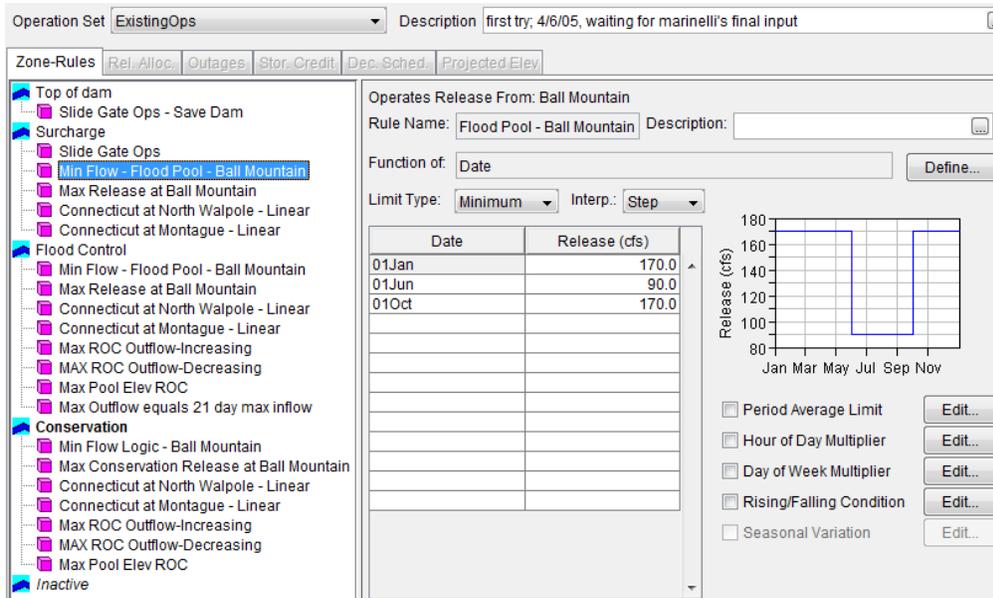


Figure 9: Reservoir Editor: Operations Tab – Existing Ops OpSet – Min flow-Flood pool-Ball Mountain

### 4. Max Release at Ball Mountain

Figure 10 shows the content of “Max Release at Ball Mountain” rule. This rule assigns 5000 cfs as the maximum release from dam.

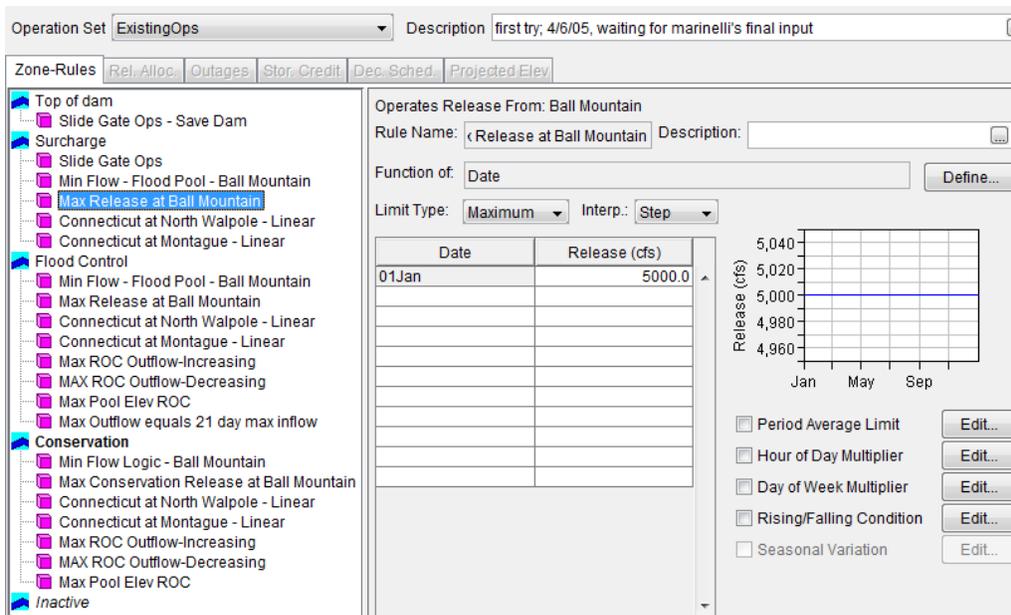


Figure 10: Reservoir Editor: Operations Tab – Existing Ops OpSet – Max Release at Ball Mountain

### 5. Connecticut at North Walpole-Linear

Figure 11 shows the content of “Connecticut at North Walpole-Linear” rule. This rule represents the maximum allowable release from dam as a function of previous day stage at North Walpole. The SOP for Ball Mountain was slightly different than the other flood control dams in that it called for an immediate reduction to 2000 cfs when a mainstem stage target was exceeded. Then the SOP says that the outflow will be directed by the Reservoir Regulation Team. The immediate reduction to 2000 cfs was accounted for in the rule and then 2000 cfs was used as the maximum when applying the linear release cutback described in the Simulation/Verification section of the report. The previous day stage was used to account for the delay that occurs between the stage exceeding the specified target and the change in operations at the flood control dams that occurs in reality.

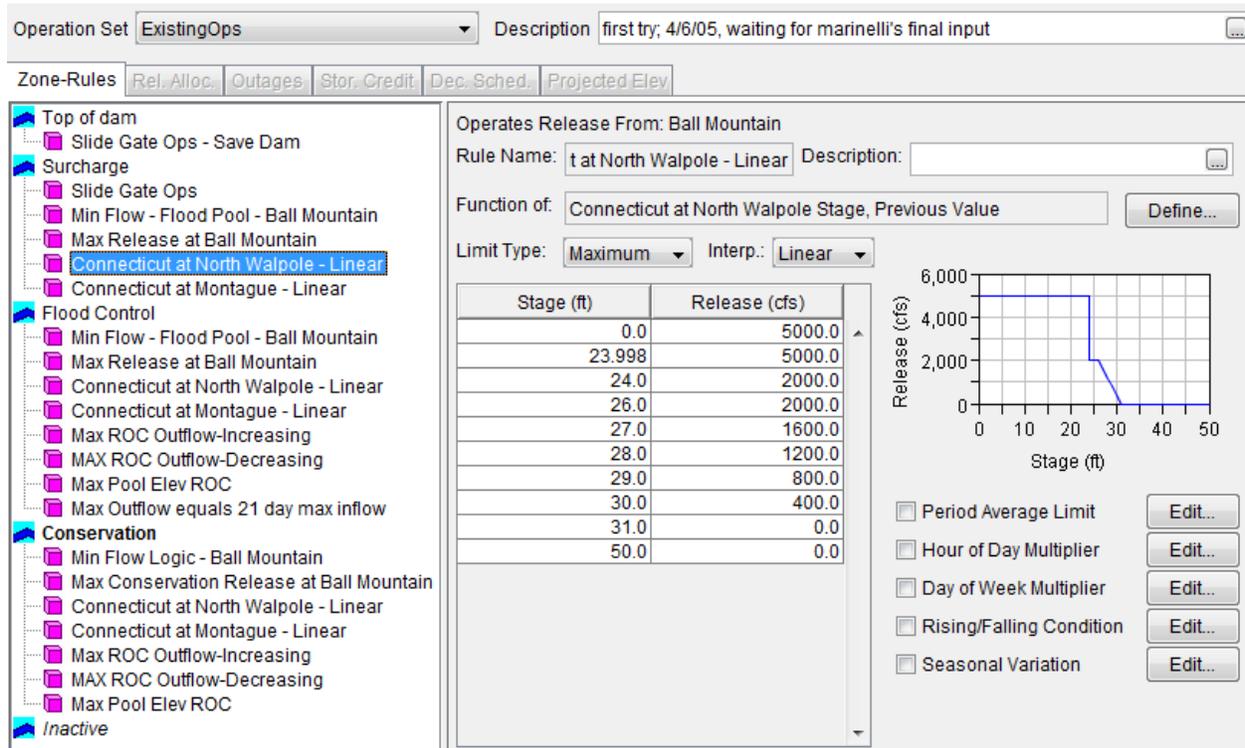


Figure 11: Reservoir Editor: Operations Tab – Existing Ops OpSet – Connecticut at North Walpole-Linear

### 6. Connecticut at Montague -Linear

Figure 12 shows the content of “Connecticut at Montague-Linear” rule. This rule represents the maximum allowable release from dam as a function of previous day stage at Montague. The SOP for Ball Mountain was slightly different than the other flood control dams in that it called for an immediate reduction to 2000 cfs when a mainstem stage target was exceeded. Then the SOP says that the outflow will be directed by the Reservoir Regulation Team. The immediate reduction to 2000 cfs was accounted for in the rule and then 2000 cfs was used as the maximum when applying the linear release cutback described in the Simulation/Verification section of the report. The previous day stage was used to account for the delay that occurs between the stage exceeding the specified target and the change in operations at the flood control dams that occurs in reality.

Operation Set: ExistingOps | Description: first try; 4/6/05, waiting for marinelli's final input

Zone-Rules: Rel. Alloc. | Outages | Stor. Credit | Dec. Sched. | Projected Eley

Operates Release From: Ball Mountain

Rule Name: cticut at Montague - Linear | Description: ...

Function of: Connecticut at Montague Stage, Previous Value | Define...

Limit Type: Maximum | Interp.: Linear

Stage (ft)	Release (cfs)
0.0	5000.0
22.998	5000.0
23.0	2000.0
26.0	2000.0
27.0	1600.0
28.0	1200.0
29.0	800.0
30.0	400.0
31.0	0.0
50.0	0.0

Graph: Release (cfs) vs Stage (ft). The graph shows a step function where release drops from 5000 cfs to 2000 cfs at 23 ft, and then decreases linearly to 0 cfs at 31 ft.

Options:  Period Average Limit | Edit...  
 Hour of Day Multiplier | Edit...  
 Day of Week Multiplier | Edit...  
 Rising/Falling Condition | Edit...  
 Seasonal Variation | Edit...

Figure 12: Reservoir Editor: Operations Tab – Existing Ops OpSet – Connecticut at Montague-Linear

### 7. MAX ROC Outflow-Increasing

Figure 13 shows the content of “MAX ROC Outflow-Increasing” rule. This rule shows the maximum allowable increasing release rate of change as a function of release from Ball Mountain dam.

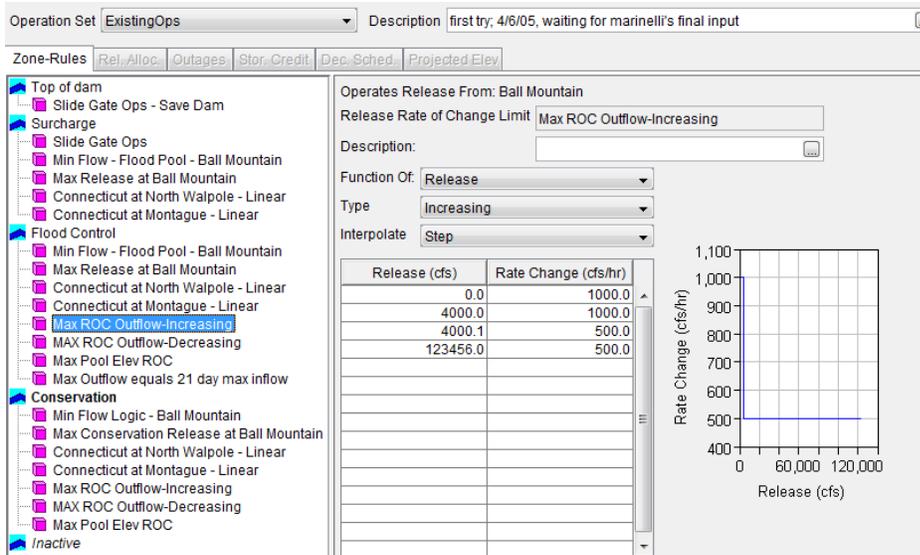


Figure 13: Reservoir Editor: Operations Tab – Existing Ops OpSet – MAX ROC Outflow-Increasing

### 8. MAX ROC Outflow-Decreasing

Figure 14 shows the content of “MAX ROC Outflow-Decreasing” rule. This rule shows the maximum allowable decreasing release rate of change.

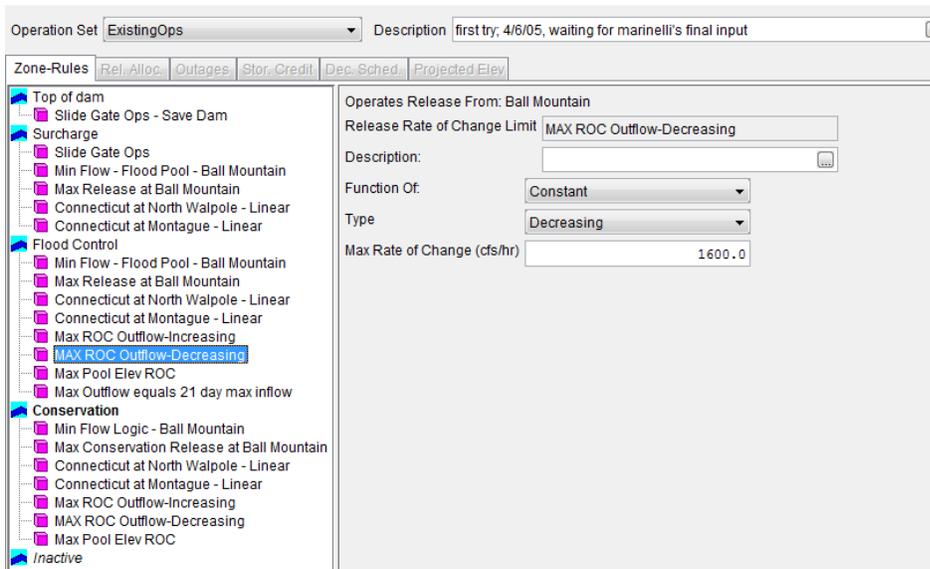


Figure 14: Reservoir Editor: Operations Tab – Existing Ops OpSet – MAX ROC Outflow-Decreasing

### 9. MAX Pool Elev ROC

Figure 15 shows the content of “MAX Pool Elev ROC” rule. This rule shows the maximum allowable decreasing pool elevation rate of change.

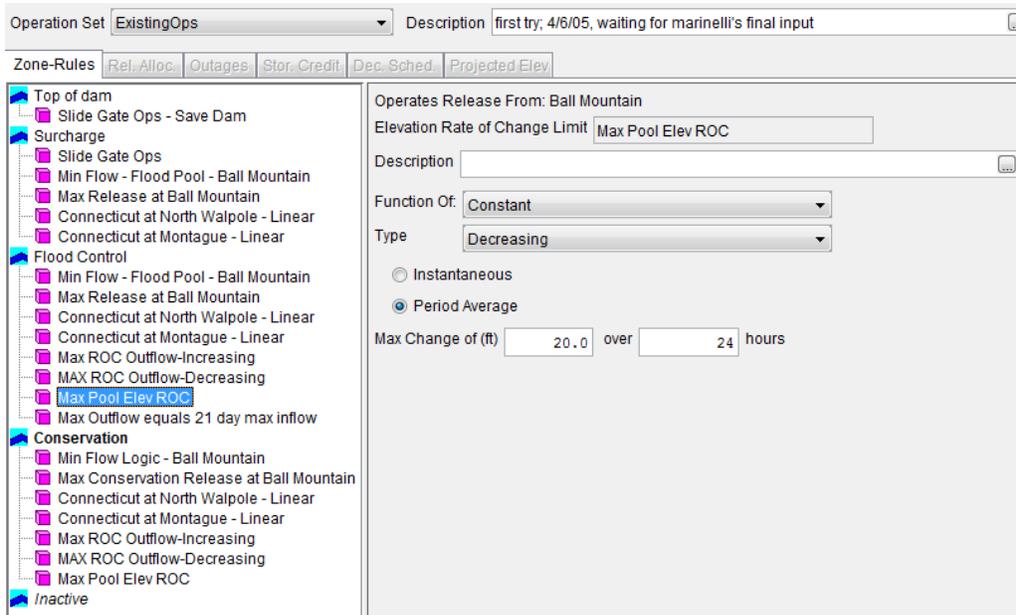


Figure 15: Reservoir Editor: Operations Tab – Existing Ops OpSet – MAX Pool Elev ROC

### 10. MAX Outflow equals 21 day max inflow

Figure 16 shows the content of “MAX outflow equals 21 day max inflow” rule. This rule represents the maximum release from dam as a function of the previous 3 weeks of inflow.

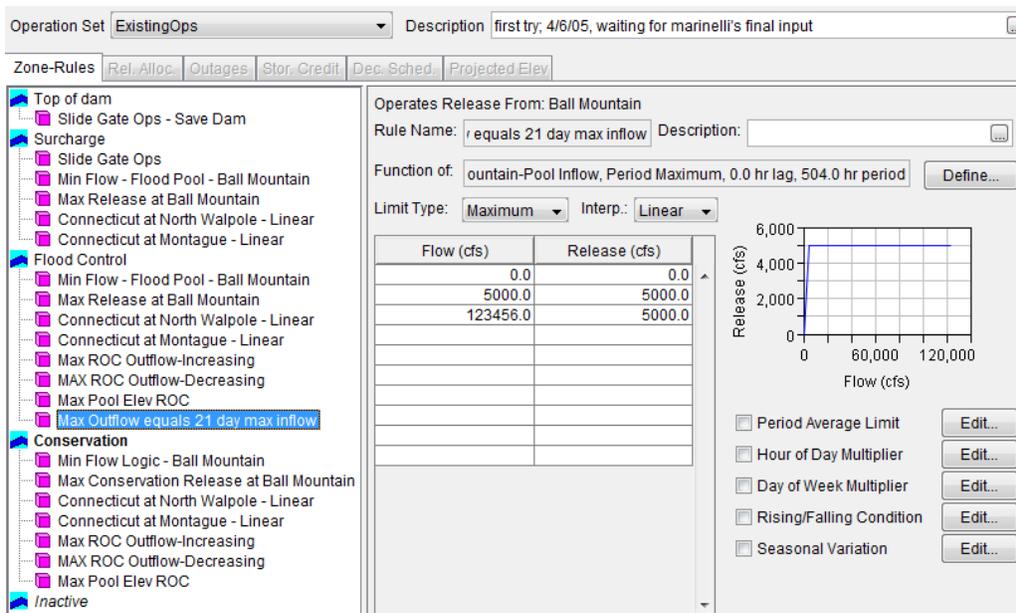


Figure 16: Reservoir Editor: Operations Tab – Existing Ops OpSet – MAX outflow equals 21 day max inflow

### 11. Min Flow Logic – Ball Mountain

Figure 17 shows the content of “Min Flow Logic – Ball Mountain” rule. This rule describes a seasonal minimum flow rule from the dam as a function of flow at Ball Mountain.

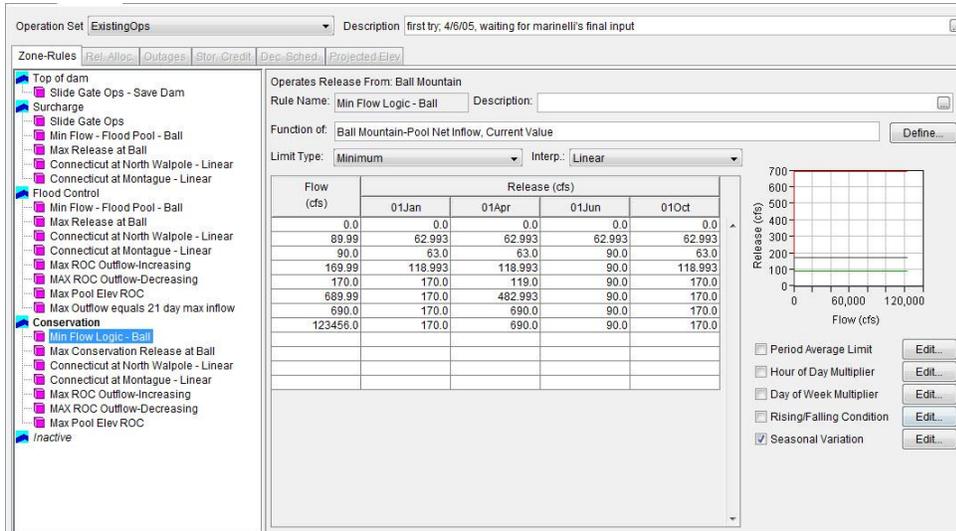


Figure 17: Reservoir Editor: Operations Tab – Existing Ops OpSet – Min Flow Logic – Ball Mountain

### 12. Max Conservation Release at Ball

Figure 18 shows the content of “Max Conservation Release at Ball” rule. This rule represents the maximum allowable release from Ball Mountain when the pool is in the conservation zone. This rule is unique to Ball Mountain and Townshend.

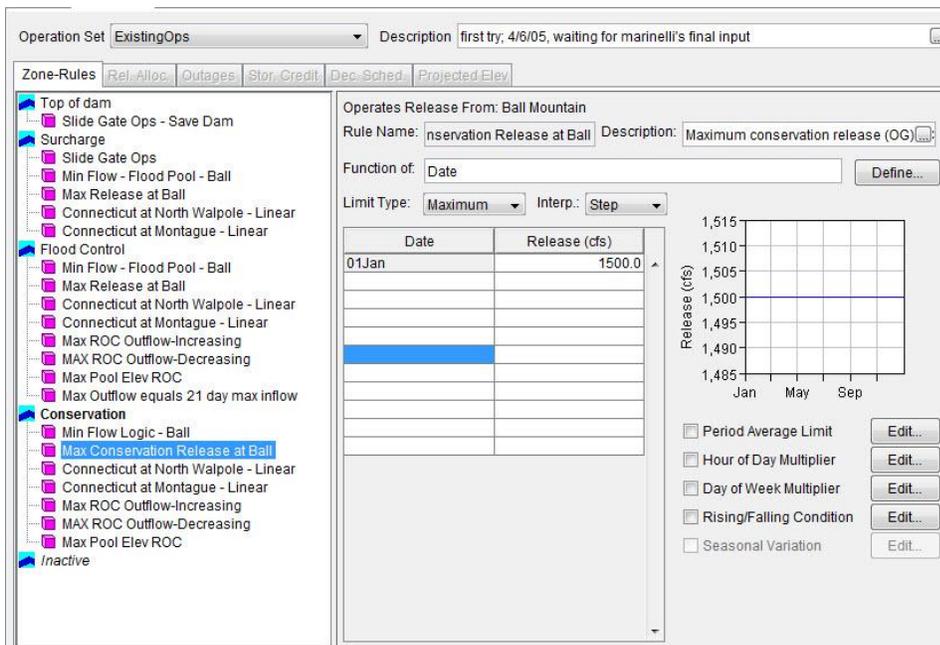


Figure 18: Reservoir Editor: Operations Tab – Existing Ops OpSet – Max Conservation Release at Ball

## Barkhamsted

### I. Overview

Construction of Barkhamsted Reservoir and Saville Dam were completed in 1940. It is owned and operated by the Hartford Metropolitan District Commission(MDC) and serves as the principal drinking water source for the city of Hartford, CT.

Figure 1 shows the location of Saville Dam and Barkhamsted reservoir as it is represented in the HEC-ResSim model, and Figure 2 shows a view from Saville Dam.

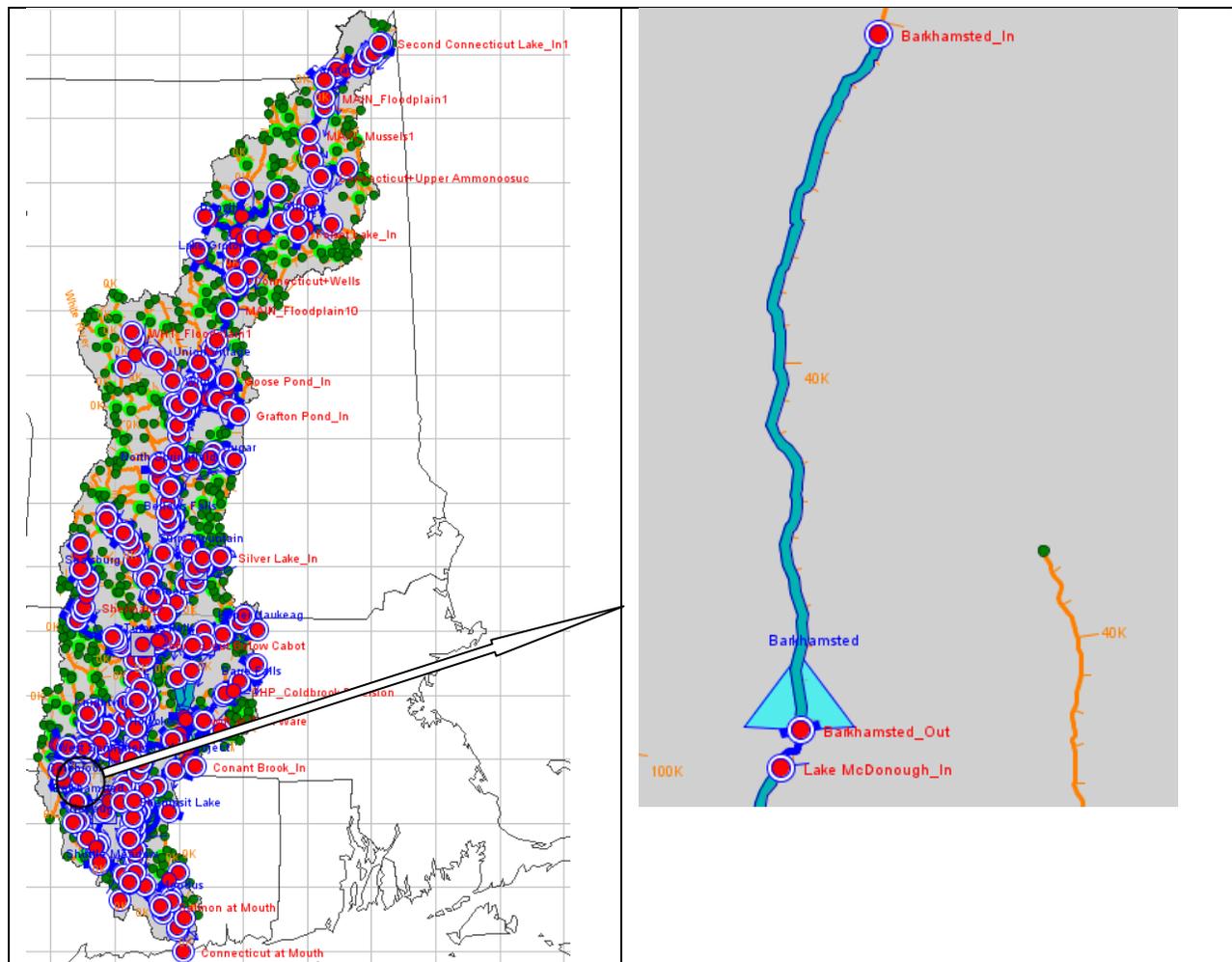


Figure 1: HEC-ResSim Map Display Showing Location of Barkhamsted reservoir



**Figure 2: Photo of Barkhamsted reservoir**

## **II. Physical Characteristics**

The physical characteristics of the reservoir are separated between the Pool and the Dam in the HEC-ResSim model. The elevation-storage-area defines the pool as shown in Figure 3<sup>2</sup>. The dam consists of one controlled spillway as shown in Figure 4<sup>3</sup>.

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<sup>2</sup> The Metropolitan District Hartford County, Conn. Barkhamsted Reservoir Available Capacity in Million Gallons. 1999.

<sup>3</sup> Adamec, K. Farmington Model Documentation. University of Massachusetts, 2009.

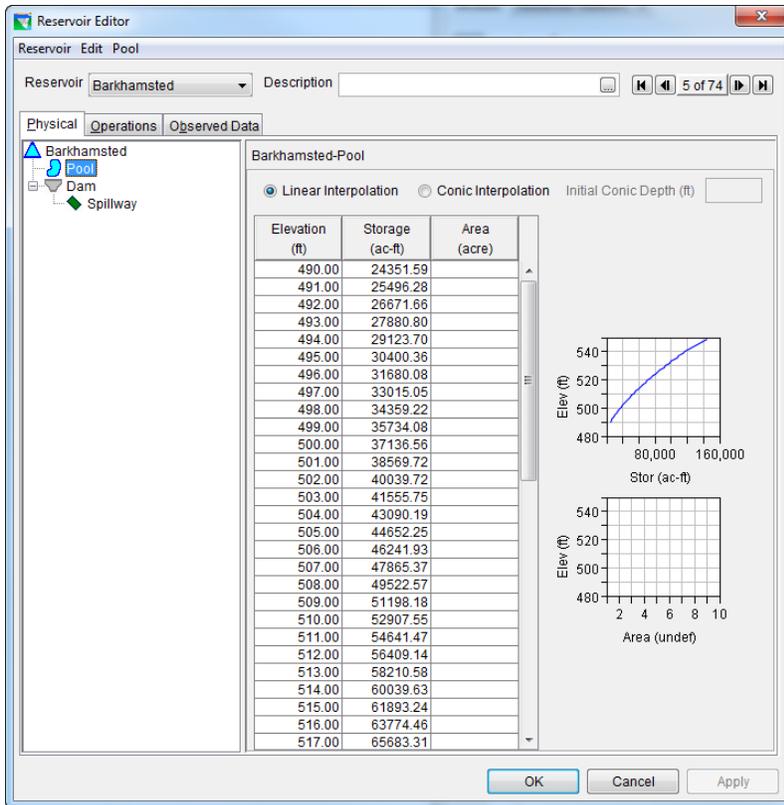


Figure 3: Reservoir Editor -- Physical Tab -- Pool

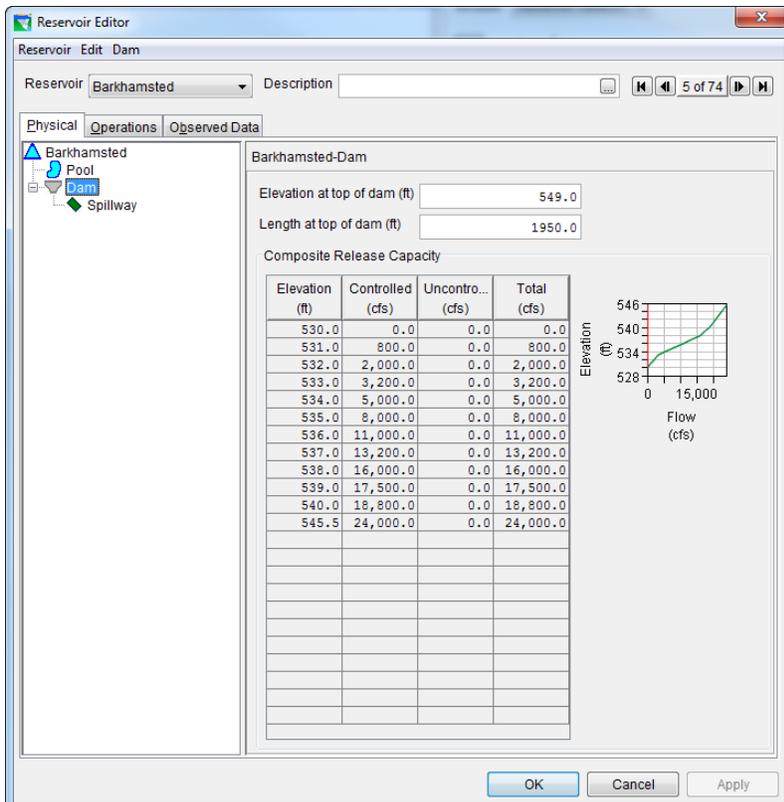


Figure 4: Reservoir Editor -- Physical Tab -- Dam

### III. Operations

#### A. Operation Set

Zones are used to define the operational storage in the reservoir to determine the reservoir release through analysis of the rules contained within each zone. Figure 5 shows the definition of Barkhamsted's "Existing Ops" operational zones, which consist of the zones Top of Dam (549 ft), Conservation (530 ft), and Inactive (490 ft)<sup>2</sup>.

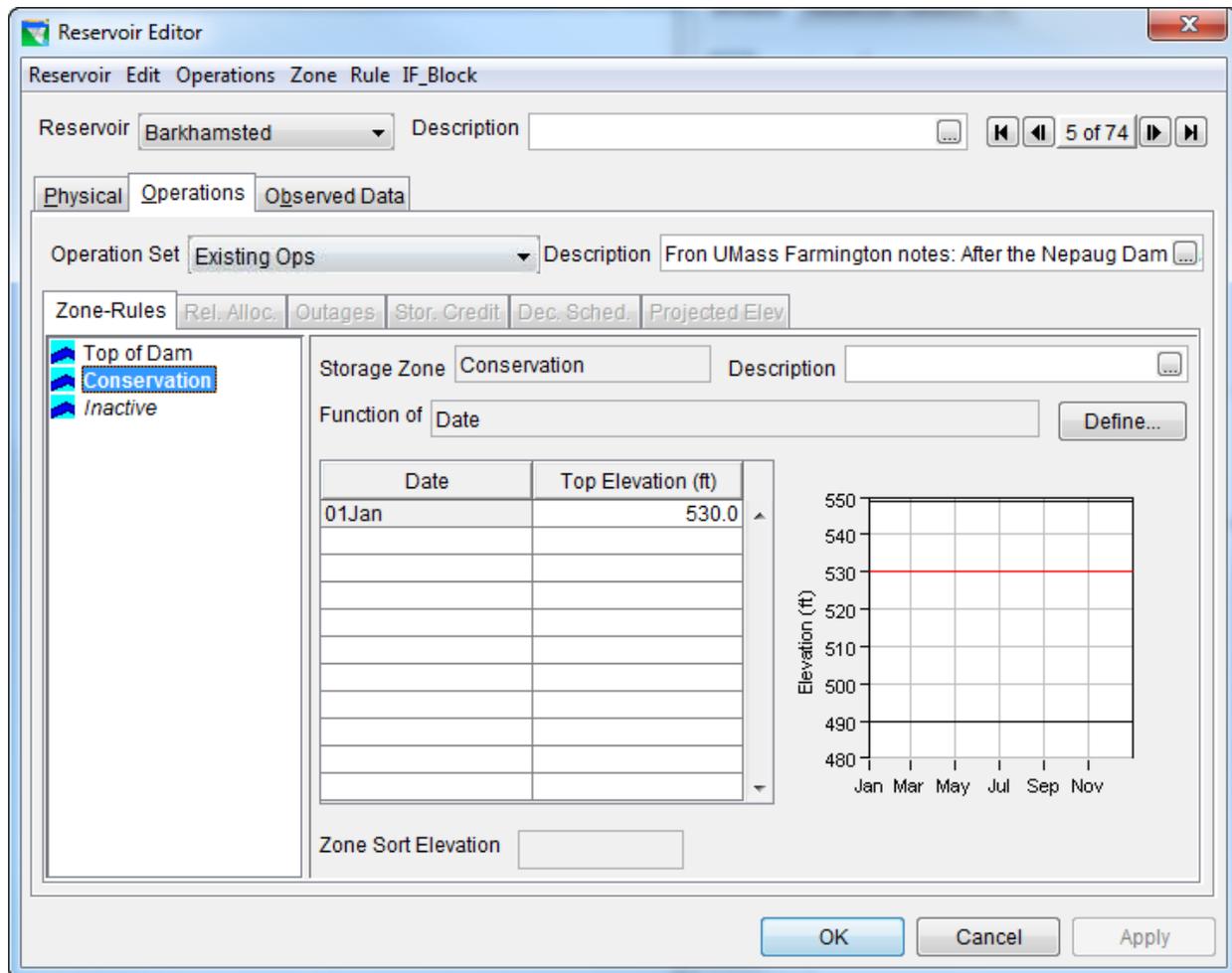


Figure 5: Reservoir Editor -- Operations Tab – Existing Ops OpSet

#### B. Rule Illustrations

The operation set for Barkhamsted has no operating rules, making it a through flow reservoir. The pool elevation will remain at the top of conservation unless the inflow exceeds the total release capacity. There is a water supply time series associated with Barkhamsted described in the Water Supply section of the report.

# Barre Falls

## I. Overview

The Barre Falls Dam is a dam in Barre, Massachusetts on the Ware River. It was constructed between 1956 and 1958 by the US Army Corps of Engineers and is still owned and operated by the Corps. It is primarily used for flood control but is also used for recreation.

Figure 1 shows the location of Barre Falls Dam as it is represented in the HEC-ResSim model. Figure 2 shows a photo of the dam.

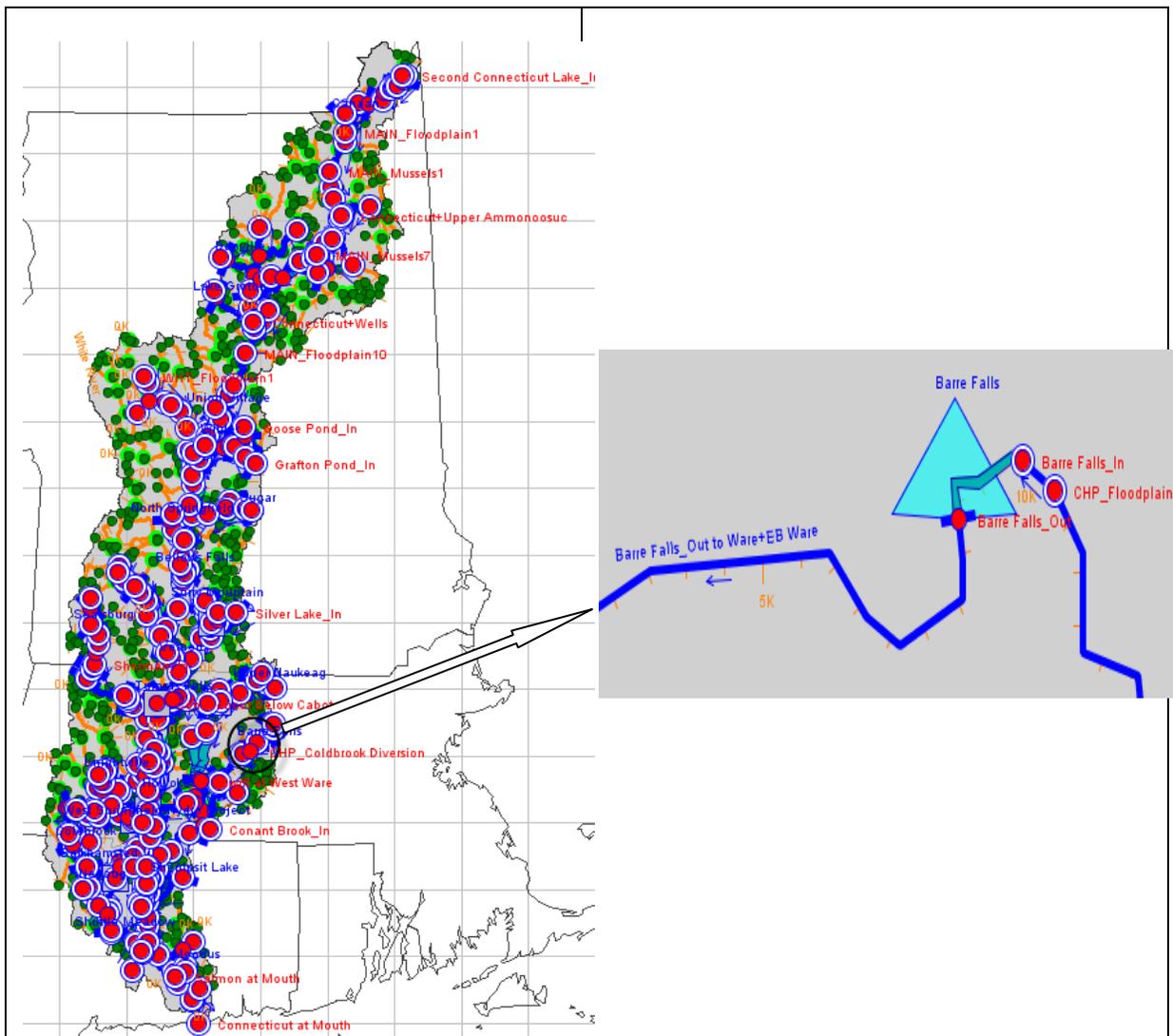


Figure 1: HEC-ResSim Map Display Showing Location of Barre Falls dam



Figure 2: Photo of Barre Falls Dam.

## II. Physical Characteristics

The physical characteristics of the reservoir are separated between the Pool and the Dam in the HEC-ResSim model. The elevation-storage-area defines the pool as shown in Figure 3. The dam consists of two types of outlets: (1) controlled Outlet, and (2) uncontrolled spillway, as shown in Figure 4. All physical and operations data were provided by US Army Corps New England District, through both a previously created ResSim model and the Reservoir Regulation Team website<sup>4</sup>.

<sup>4</sup> [http://rsgisias.crrel.usace.army.mil/nae/cwms\\_map.map\\_index](http://rsgisias.crrel.usace.army.mil/nae/cwms_map.map_index)

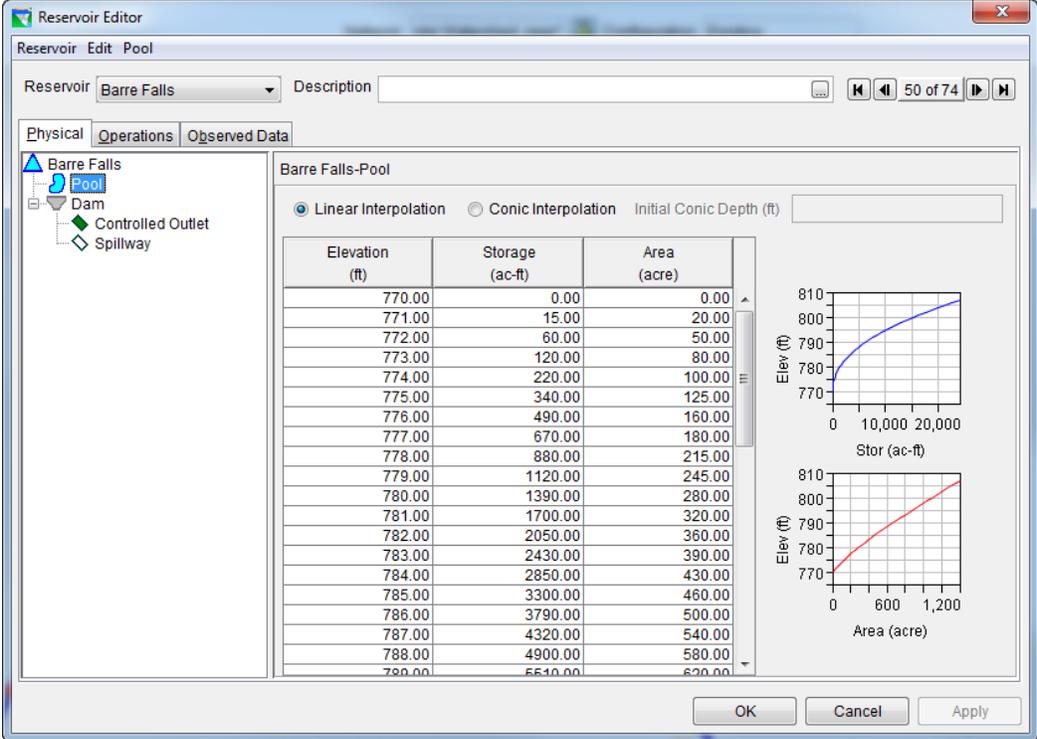


Figure 3: Reservoir Editor: Physical Tab -- Pool

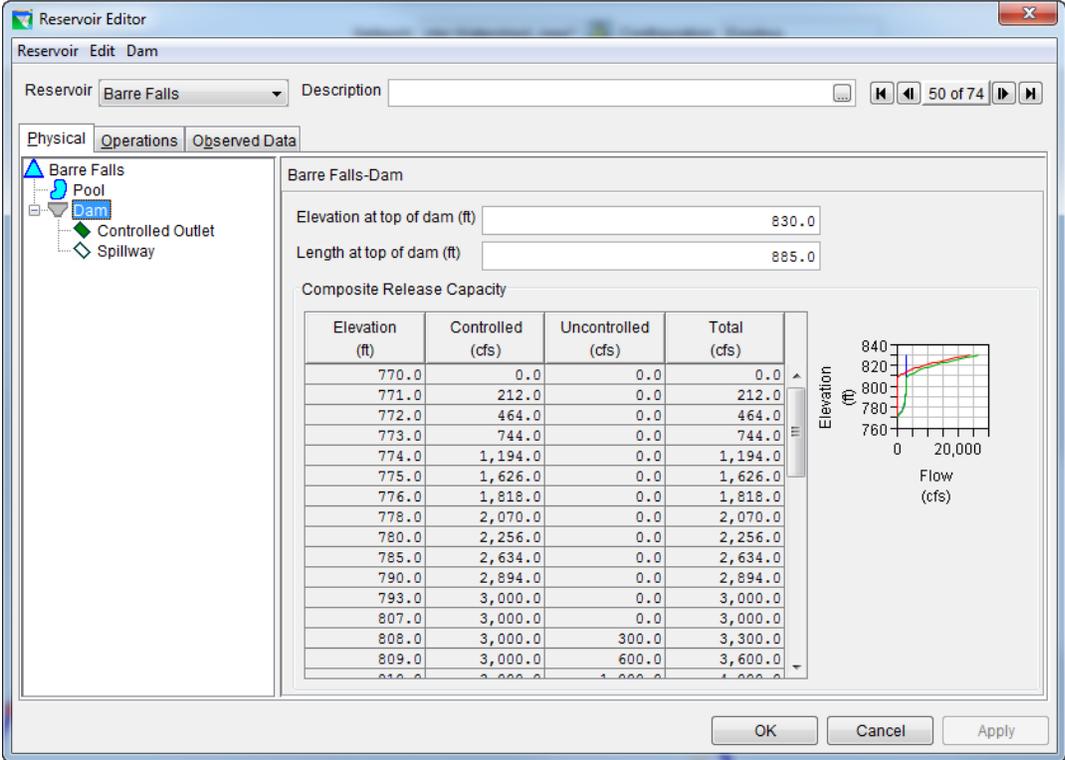


Figure 4: Reservoir Editor: Physical Tab -- Dam

### III. Operations

#### A. Operation Set

Zones are used to define the operational storage in the reservoir to determine the reservoir release through analysis of the rules contained within each zone. Figure 5 shows the definition of Barre Falls’s “Existing Ops” operational zones, which consist of zones of Surchage (830 ft), Flood Control (807 ft), Conservation (772-776 ft), and Inactive zone (770 ft).

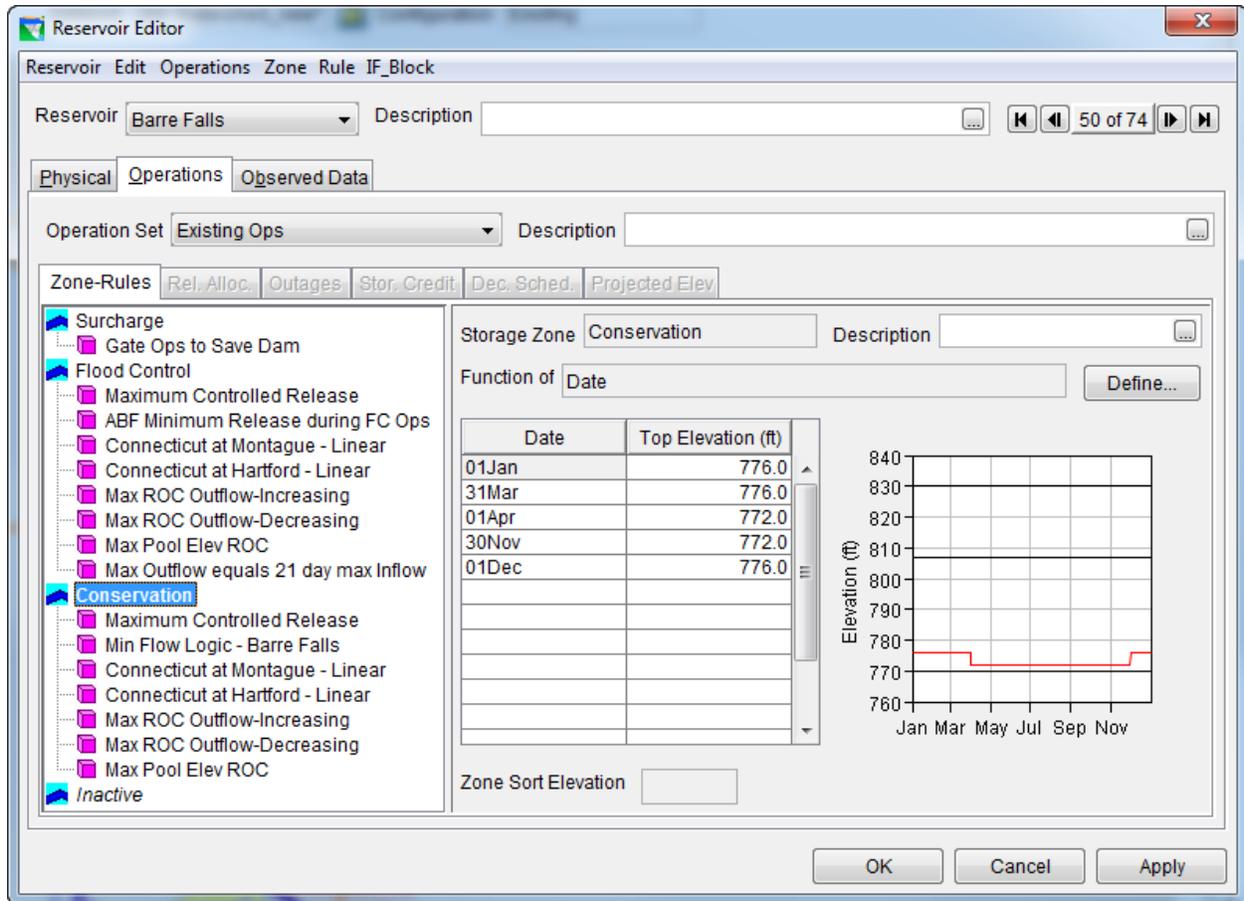


Figure 5: Reservoir Editor: Operations Tab –Existing Ops OpSet – Guide Curve

## B. Rule Illustrations

Figure 6 shows a set of operational rules specified for each zone that reflects the operation set named Existing Ops. As described in the Simulation/Verification section of the report, adjustments were made to the operations to closer match gauge data.

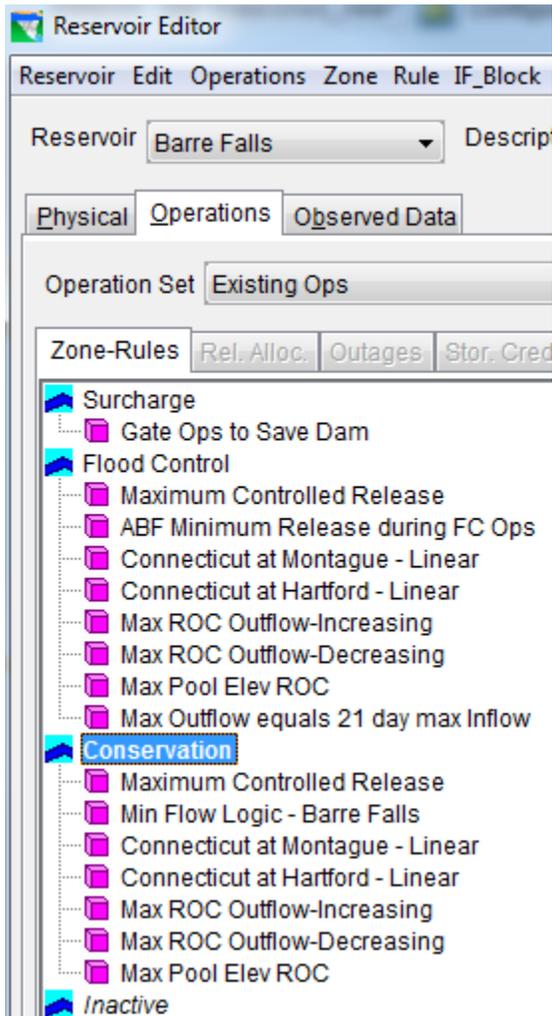


Figure 6: Reservoir Editor: Operations Tab – Existing Ops OpSet – Zones and Rules

## C. Rule Descriptions

### 1. Gate Ops to Save Dam

Figure 7 shows the content of “Gate Ops to Save Dam” rule. This rule represents the maximum allowable release from controlled outlet as a function of pool elevation when the pool is in surcharge zone.

The screenshot displays the 'Operations Tab' for the 'Existing Ops' set. The 'Gate Ops to Save Dam' rule is selected in the sidebar. The main configuration area shows the following details:

- Operates Release From:** Barre Falls-Controlled Outlet
- Rule Name:** Gate Ops to Save Dam
- Function of:** -Pool Elevation, Period Average, 0.0 hr lag, 48.0 hr period
- Limit Type:** Maximum
- Interp.:** Linear

Elev (ft)	Release (cfs)
807.0	1000.0
808.0	700.0
809.0	400.0
810.0	660.0
813.0	1060.0
816.0	1860.0
819.0	3440.0
830.0	3440.0

The graph on the right plots Release (cfs) against Elevation (ft), showing a curve that starts at approximately 1000 cfs at 807 ft, dips to 400 cfs at 809 ft, and then rises to a constant 3440 cfs from 819 ft to 830 ft.

Figure 7: Reservoir Editor: Operations Tab – Existing Ops OpSet –Gate Ops to Save Dam

### 2. Maximum Controlled Release

Figure 8 shows the content of “Maximum Controlled Release” rule. This rule shows the maximum release from controlled outlet.

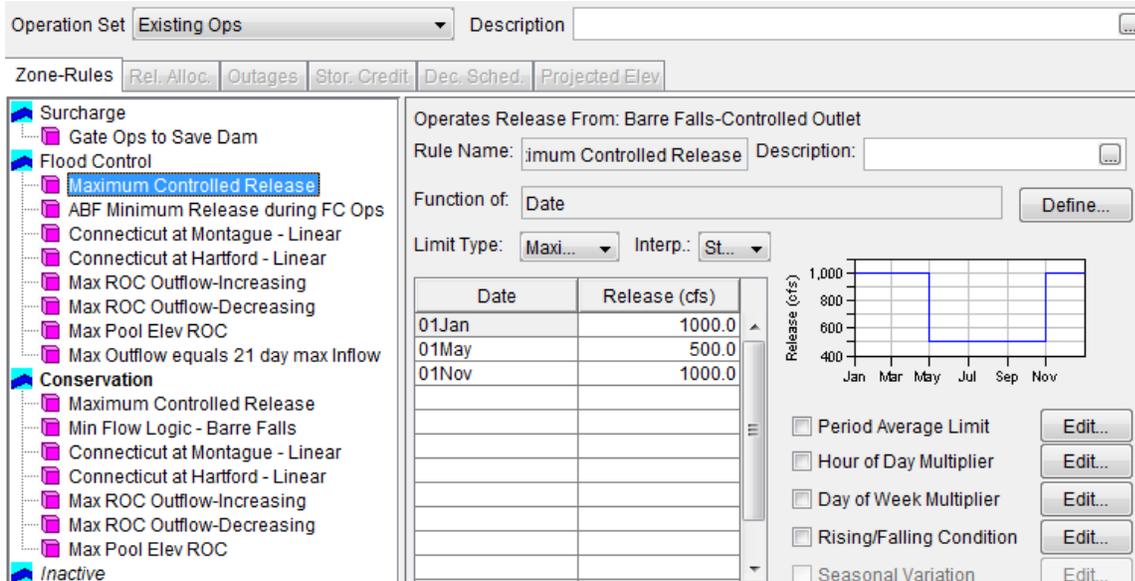


Figure 8: Reservoir Editor: Operations Tab – Existing Ops OpSet – Maximum Controlled Release

### 3. ABF Minimum Release during FC Ops

Figure 9 shows the content of “ABF Minimum Release during FC Ops” rule. This rule assigns a 30 cfs release from the dam during flood control operations.

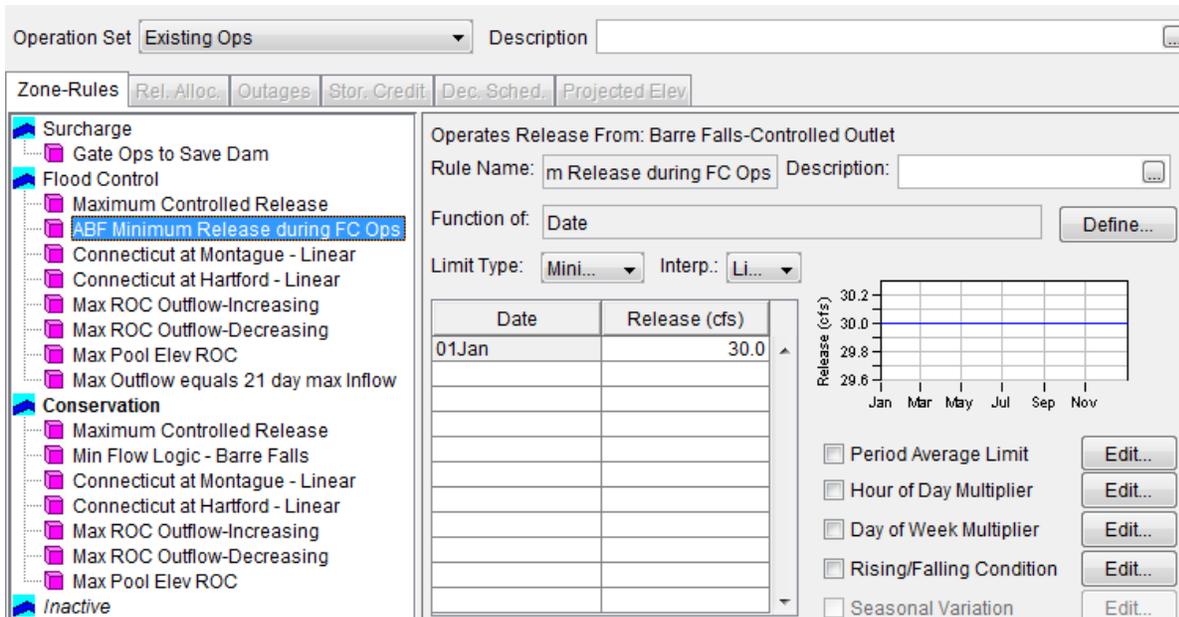


Figure 9: Reservoir Editor: Operations Tab – Existing Ops OpSet – ABF Minimum Release during FC Ops

#### 4. Connecticut at Montague-Linear

Figure 10 shows the content of “Connecticut at Montague-Linear” rule. This rule represents the maximum allowable release from the dam as a function of the previous day stage at Montague. The previous day stage was used to account for the delay that occurs between the stage exceeding the specified target and the change in operations at the flood control dams that occurs in reality.

The screenshot shows the 'Operations Tab' for the 'Existing Ops' set. The 'Zone-Rules' section is expanded to show 'Connecticut at Montague - Linear' under the 'Flood Control' category. The main configuration area for this rule is as follows:

- Operates Release From:** Barre Falls
- Rule Name:** Connecticut at Montague - Linear
- Function of:** Connecticut at Montague Stage, Previous Value
- Limit Type:** Maximum
- Interp.:** Linear

Stage (ft)	Release (cfs)
0.0	1000000.0
25.99	1000000.0
26.0	1000.0
27.0	800.0
28.0	600.0
29.0	400.0
30.0	200.0
31.0	30.0
50.0	30.0

The graph on the right plots Release (cfs) on the y-axis (0 to 1,200,000) against Stage (ft) on the x-axis (0 to 50). The data points from the table are plotted, showing a sharp drop in release at 26.0 ft stage and a gradual decrease thereafter.

Figure 10: Reservoir Editor: Operations Tab – Existing Ops OpSet – Connecticut at Montague-Linear

**5. Connecticut at Hartford-Linear**

Figure 11 shows the content of “Connecticut at Hartford-Linear” rule. This rule represents the maximum allowable release from dam as a function of previous day stage at Hartford. The previous day stage was used to account for the delay that occurs between the stage exceeding the specified target and the change in operations at the flood control dams that occurs in reality.

The screenshot shows the 'Operations Tab' in the Reservoir Editor. The 'Existing Ops' set is selected. The 'Zone-Rules' tree on the left has 'Connecticut at Hartford - Linear' highlighted under the 'Flood Control' category. The main configuration area shows the rule name and function. The 'Function of' is 'Connecticut at Hartford Stage, Previous Value'. The 'Limit Type' is 'Maximum' and 'Interp.' is 'Linear'. A table shows the release limits for different stages, and a graph plots Release (cfs) against Stage (ft).

Stage (ft)	Release (cfs)
0.0	1000000.0
17.99	1000000.0
18.0	1000.0
19.0	800.0
20.0	600.0
21.0	400.0
22.0	200.0
23.0	30.0
50.0	30.0

**Figure 11: Reservoir Editor: Operations Tab – Existing Ops OpSet – Connecticut at Hartford-Linear**

### 6. Max ROC Outflow-Increasing

Figure 12 shows the content of “MAX ROC Outflow-Increasing” rule. This rule shows the maximum allowable increasing release rate of change as a function of release from Barre falls dam.

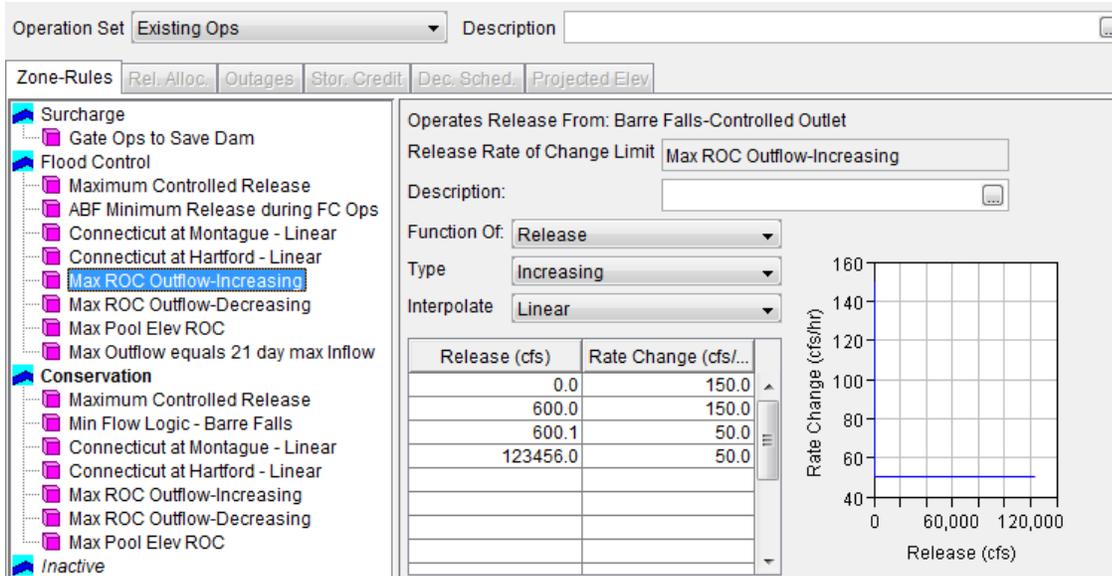


Figure 12: Reservoir Editor: Operations Tab – Existing Ops OpSet –MAX ROC Outflow-Increasing

### 7. Max ROC Outflow-Decreasing

Figure 13 shows the content of “MAX ROC Outflow-Decreasing” rule. This rule shows the maximum allowable decreasing release rate of change.

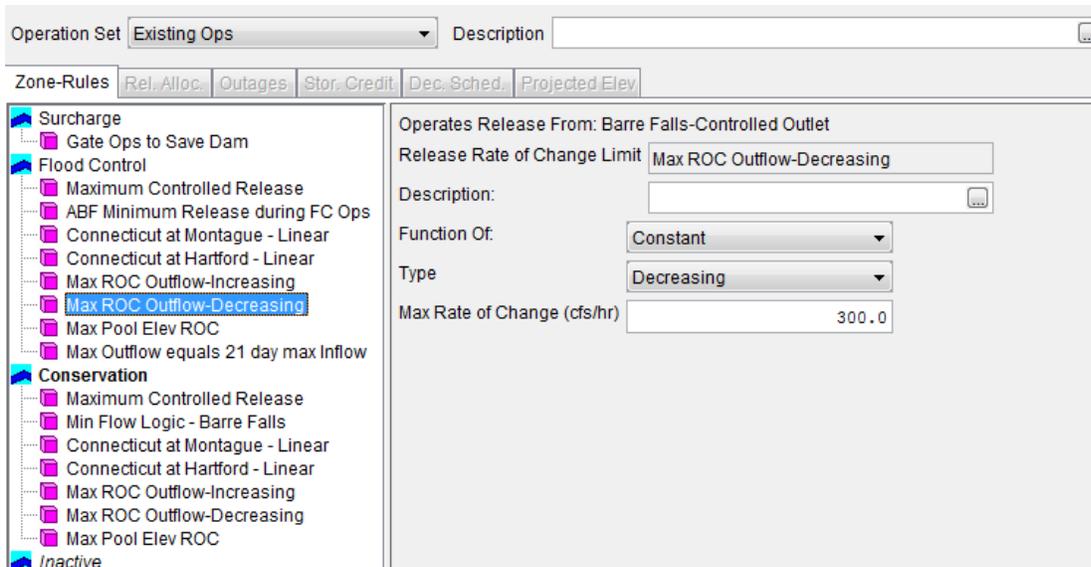


Figure 13: Reservoir Editor: Operations Tab – Existing Ops OpSet – MAX ROC Outflow-Decreasing

**8. Max Pool Elev ROC**

Figure 14 shows the content of “Max Pool Elev ROC” rule. This rule shows the maximum allowable decreasing pool elevation rate of change.

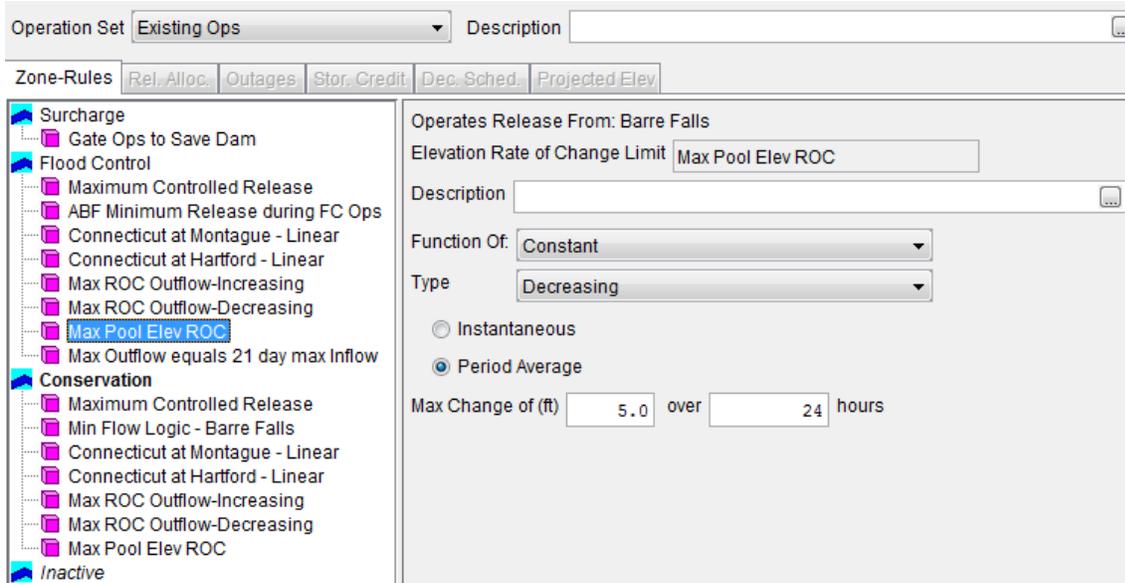


Figure 14: Reservoir Editor: Operations Tab – Existing Ops OpSet –Max Pool Elev ROC

**9. Max Outflow equals 21 day max inflow**

Figure 15 shows the content of “Max Outflow equals 21 day max inflow” rule. This rule represents the maximum release from dam as a function of the previous 3 weeks of inflow.

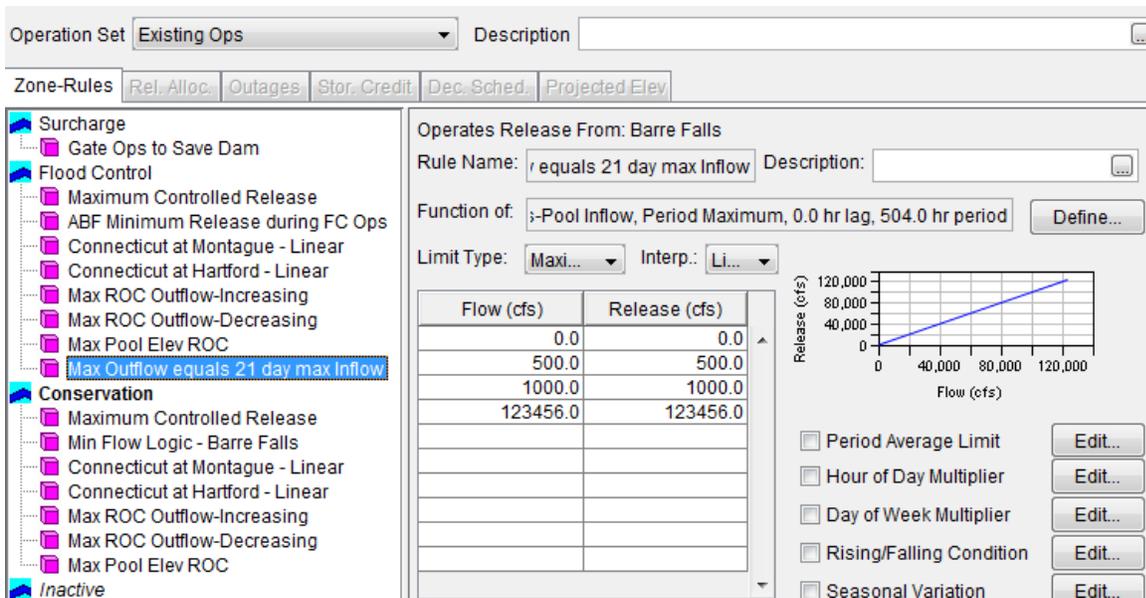


Figure 15: Reservoir Editor: Operations Tab – Existing Ops OpSet – Max Outflow equals 21 day max inflow

### 10. Min Flow Logic-Barre Falls

Figure 16 shows the content of “Min Flow Logic-Barre Falls” rule. This rule describes a seasonal minimum flow rule from controlled outlets as a function of inflow at Barre falls.

The screenshot displays the 'Operations Tab' in the 'Existing Ops OpSet' for the 'Min Flow Logic-Barre Falls' rule. The rule is configured with the following parameters:

- Operates Release From:** Barre Falls-Controlled Outlet
- Rule Name:** in Flow Logic - Barre Falls
- Function of:** Barre Falls-Pool Net Inflow, Current Value
- Limit Type:** Minimum
- Interp.:** Linear

The main configuration area contains a table with the following data:

Flow (cfs)	Release (cfs)			
	01Jan	01Apr	01Jun	01Oct
0.0	0.0	0.0	0.0	0.0
29.99	20.993	20.993	20.993	20.993
30.0	21.0	21.0	30.0	21.0
54.99	38.493	38.493	30.0	38.493
55.0	55.0	38.5	30.0	55.0
219.99	55.0	153.993	30.0	55.0
220.0	55.0	220.0	30.0	55.0
123456.0	55.0	220.0	30.0	55.0

To the right of the table is a graph showing 'Release (cfs)' on the y-axis (0 to 200) and 'Flow (cfs)' on the x-axis (0 to 120,000). The graph displays a horizontal line at approximately 55 cfs release for flow values above 55 cfs. Below the graph are several checkboxes for advanced settings:

- Period Average Limit
- Hour of Day Multiplier
- Day of Week Multiplier
- Rising/Falling Condition
- Seasonal Variation

Figure 16: Reservoir Editor: Operations Tab – Existing Ops OpSet – Min Flow Logic-Barre Falls

# Bashan

## I. Overview

The dam was constructed in 1939 and is used for recreation. It is owned by the state of Connecticut and is under the control of the Department of Environmental Protection. The lake area is 276 acres, about 21% of the its total drainage area. In 2011, funds were allocated to repair the dam and to decrease the risk of the dam overtopping during a flood event.

Figure 1 shows the location of Bashan reservoir as it is represented in the HEC-ResSim model. Figure 2 shows a photo of Bashan Dam.

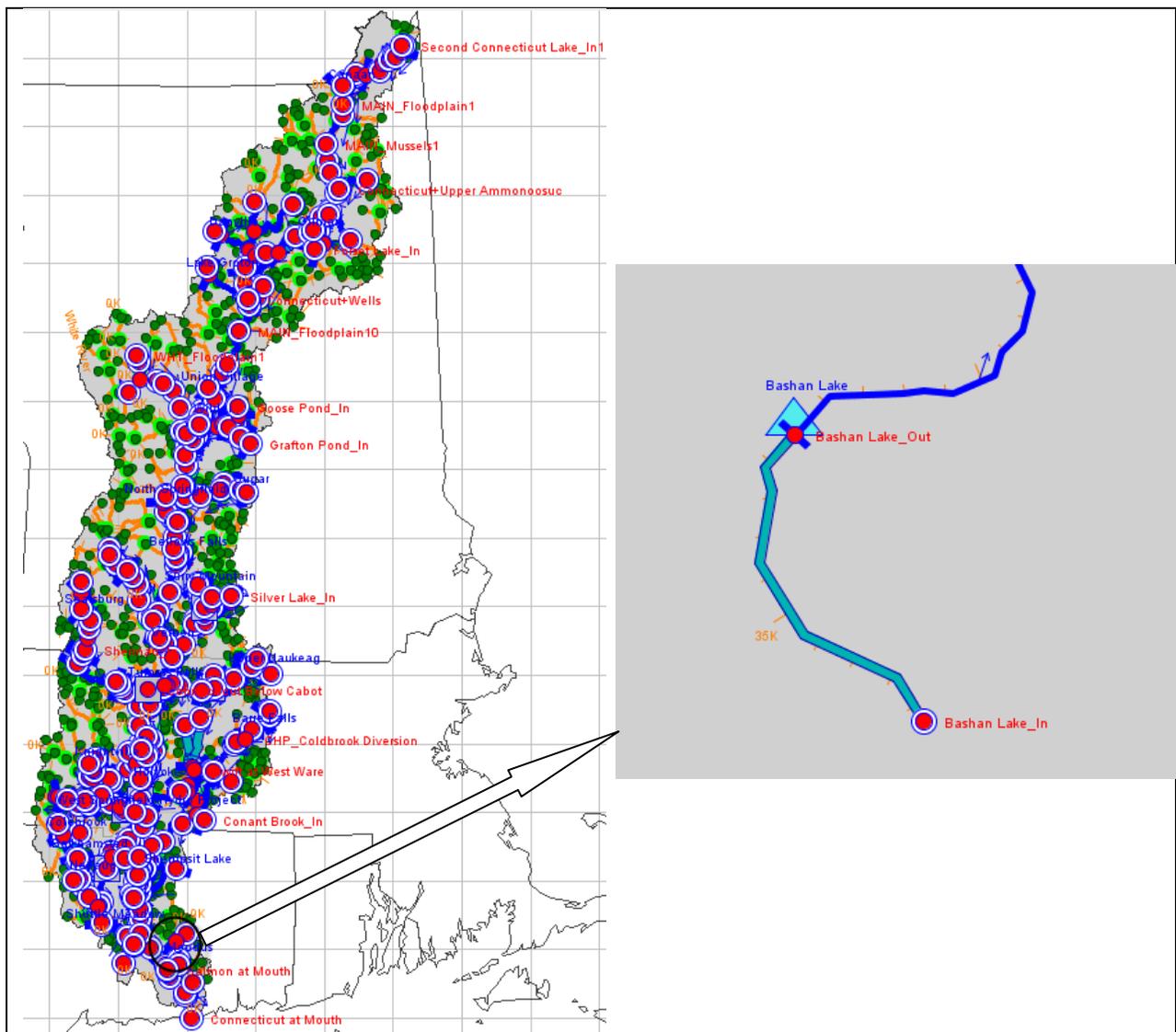


Figure 1: HEC-ResSim Map Display Showing Location of Bashan Dam



**Figure 2: Aerial photo of Bashan Lake Dam**

## **II. Physical Characteristics**

The physical characteristics of the reservoir are separated between the Pool and the Dam in the HEC-ResSim model. The elevation-storage-area defines the pool as shown in Figure 3<sup>5</sup>. The dam consists of three different outlets: (1) an uncontrolled spillway, (2) an uncontrolled right embankment, and (3) an uncontrolled left embankment as shown in Figure 4. These three uncontrolled were modeled as weirs, with data shown in Table 1<sup>6</sup>.

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<sup>5</sup> Provided by the operators of Bashan

<sup>6</sup> WMC Consulting Engineers. Preliminary Design Report. Newington, CT 2012.

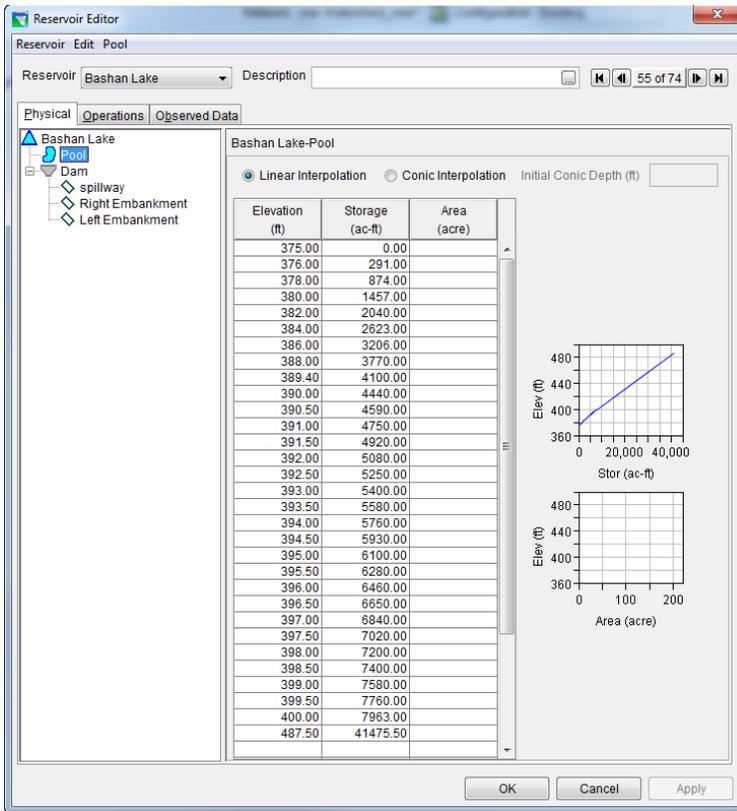


Figure 3: Reservoir Editor -- Physical Tab -- Pool

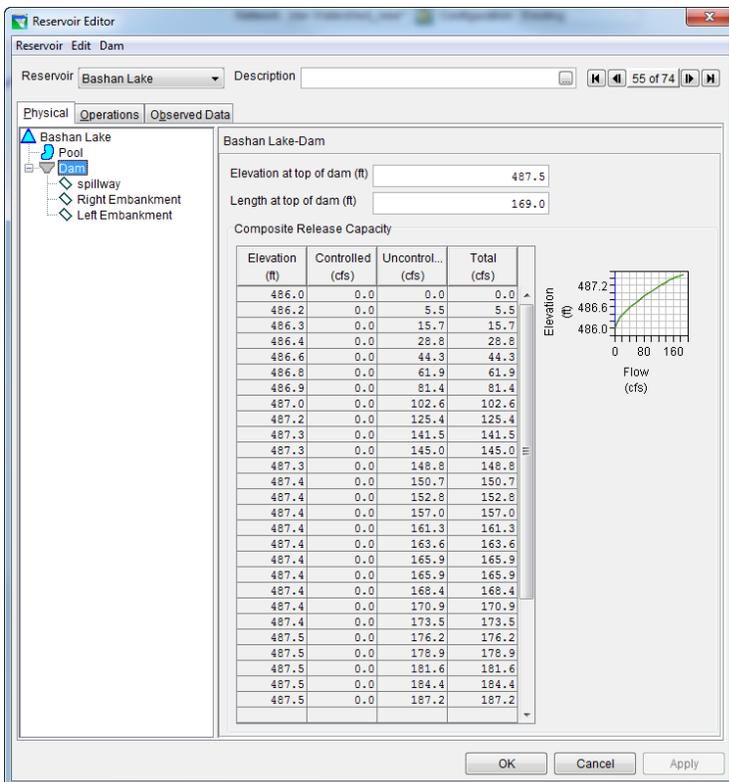


Figure 4: Reservoir Editor -- Physical Tab -- Dam

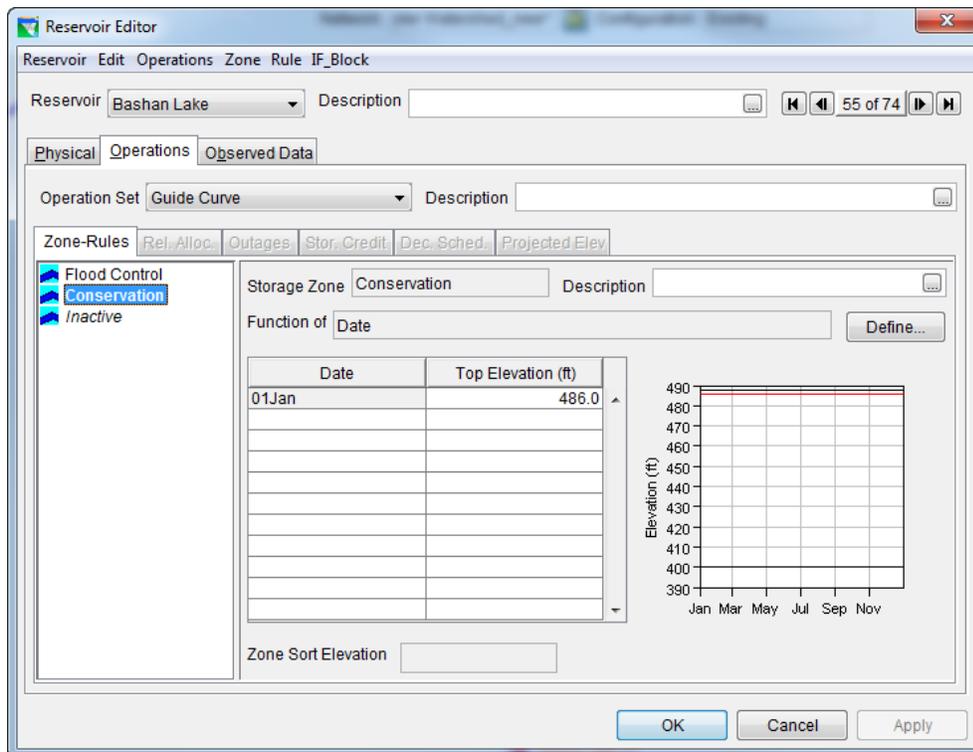
**Table 1: Weir Data**

	Outlet Elevation (ft)	Weir Coef.	Length (ft)
Spillway	486	3.3	28.9
Right Embankment	487.4	3.3	30.0
Left Embankment	487.3	3.3	30.0

### III. Operations

#### A. Operation Set

Zones are used to define the operational storage in the reservoir to determine the reservoir release through analysis of the rules contained within each zone. Figure 4 shows the definition of Bashan’s “Guide Curve” operational zones, which consist of the zones Flood Control (487.5 ft), Conservation (486 ft), and Inactive (400 ft). The zone elevations were based off the top of the elevation-storage curve and the spillway outlet elevation.



**Figure 5: Reservoir Editor -- Operations Tab – Guide Curve OpSet**

#### B. Rule Illustrations

The operation set for Bashan has no operating rules, making it a through flow reservoir. The pool elevation will remain at the top of conservation unless the inflow exceeds the total release capacity.

# Bear Swamp

## I. Overview

Bear Swamp is pump-storage and run-of-river hydropower generating facility (the run-of-river facility is called Fife Brook) on the Deerfield River in Rowe, MA. It is currently owned and operated by Brookfield Renewable Power Inc. and is primarily used for hydropower generation. It is also used to make whitewater releases for whitewater rafting.

Figure 1 shows the location of Bear Swamp Dam as it is represented in the HEC-ResSim model. Figure 2 shows a photo of Bear Swamp dam.

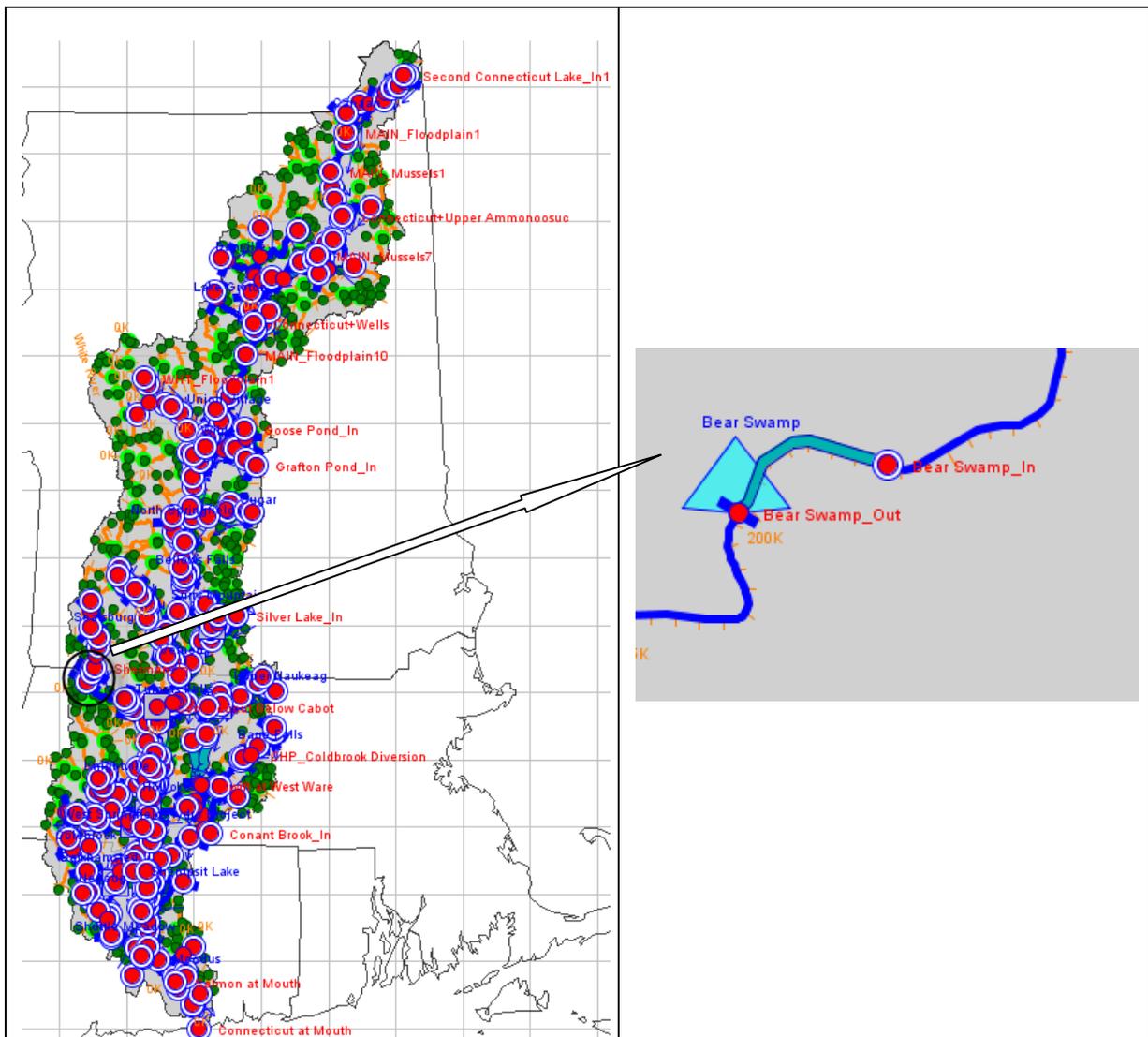


Figure 1: HEC-ResSim Map Display Showing Location of Bear Swamp dam



**Figure 2: Photo of Bear Swamp Dam**

## **II. Physical Characteristics**

Only the physical and operational characteristics of the river portion of the project are modeled. The pump-storage part of the project was not modeled because it was deemed unnecessary. The pump-storage is operates on the same volume of water, all flow from upstream is passed through the river portion of the project

The physical characteristics of the reservoir are separated between the Pool and the Dam in the HEC-ResSim model. The elevation-storage-area defines the pool as shown in Figure 3<sup>7</sup>. The dam consists of three types of outlets: (1) controlled tainter gate, (2) controlled 30 inch pipe, and (3) power plant as shown in Figure 4.

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<sup>7</sup> Brookfield Renewable Power Inc. Brookfield – Bear Swamp Pump Storage Project. 2012





## B. Rule Illustrations

Figure 6 shows a set of operational rules specified for each zone that reflects the operation set named Guide Curve.

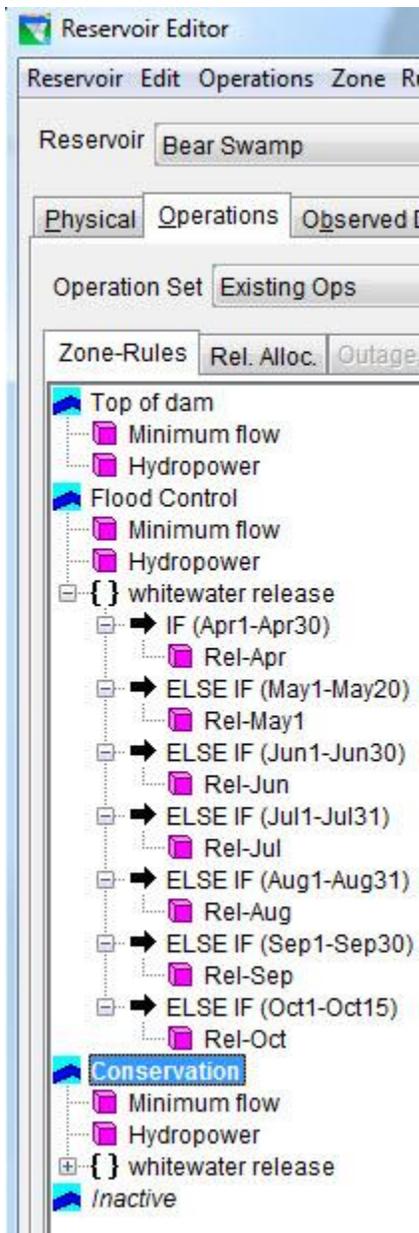


Figure 6: Reservoir Editor: Operations Tab – Existing Ops OpSet – Zones and Rules

## C. Rule Descriptions

### 1. Minimum flow

Figure 7 shows the content of “Minimum flow” rule. This rule assigns 125 cfs as a minimum release from 30 inch pipe controlled outlet.

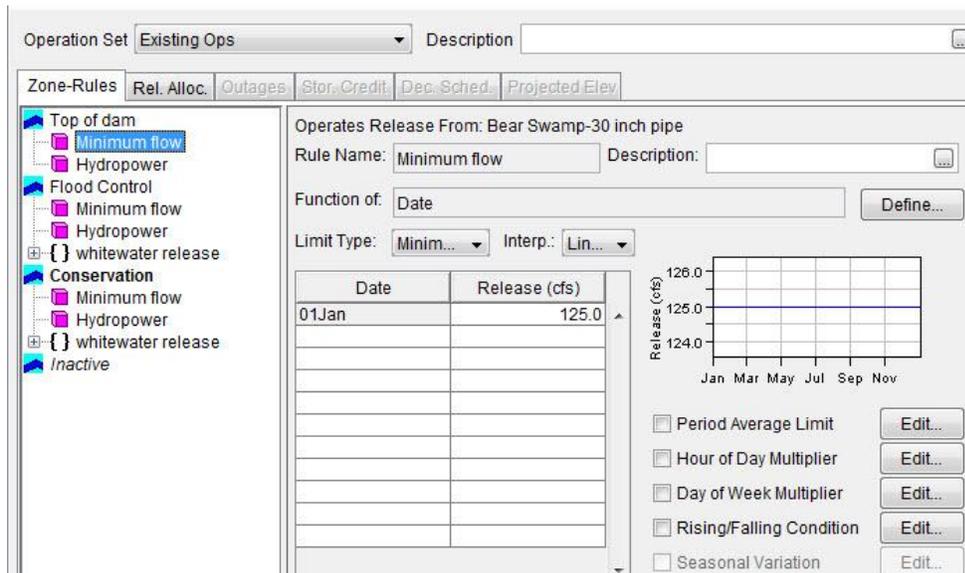


Figure 7: Reservoir Editor: Operations Tab – Existing Ops OpSet – Minimum flow

### 2. Hydropower

Figure 8 shows the content of “Hydropower” rule. This rule releases 95% of inflow through power plant as per the run-of-river hydropower strategy.

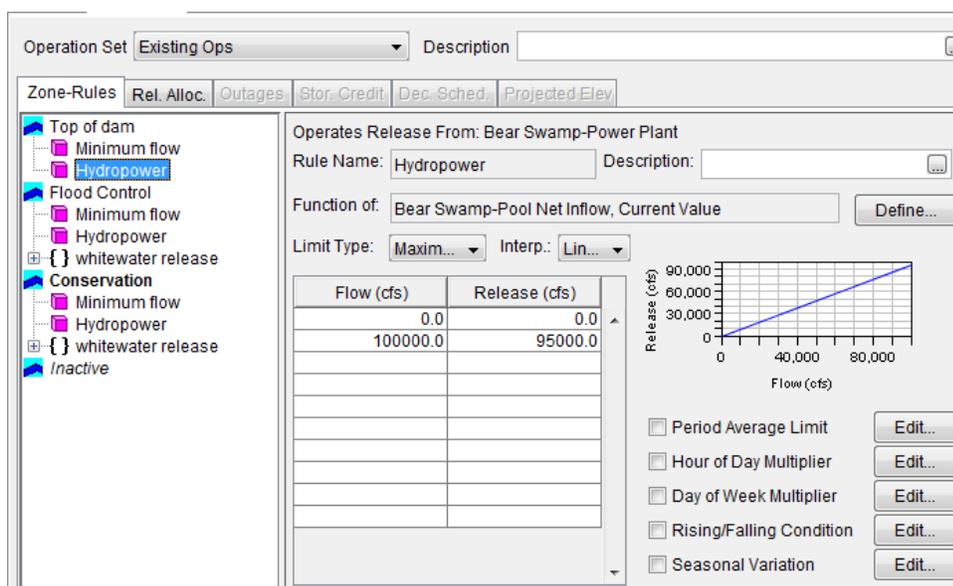


Figure 8: Reservoir Editor: Operations Tab – Existing Ops OpSet –Hydropower

### 3. Whitewater release

Figure 9 shows the content of “Whitewater release” rule. This rule releases 700 cfs through power plant with different schedules during different months of the year.

Operation Set: Existing Ops    Description: [ ]

Zone-Rules    Rel. Alloc.    Outages    Stor. Credit    Dec. Sched.    Projected Elev.

- Top of dam
  - Minimum flow
  - Hydropower
- Flood Control
  - Minimum flow
  - Hydropower
  - whitewater release**
    - IF (Apr1-Apr30)
      - Rel-Apr
    - ELSE IF (May1-May20)
      - Rel-May1
    - ELSE IF (Jun1-Jun30)
      - Rel-Jun
    - ELSE IF (Jul1-Jul31)
      - Rel-Jul
    - ELSE IF (Aug1-Aug31)
      - Rel-Aug
    - ELSE IF (Sep1-Sep30)
      - Rel-Sep
    - ELSE IF (Oct1-Oct15)
      - Rel-Oct
- Conservation
  - Minimum flow
  - Hydropower
  - whitewater release
- Inactive

Operates Release From: Bear Swamp

Name: whitewater release    Description: [ ]

Type	Name	Description
IF	Apr1-Apr30	
ELSE IF	May1-May20	
ELSE IF	Jun1-Jun30	
ELSE IF	Jul1-Jul31	
ELSE IF	Aug1-Aug31	
ELSE IF	Sep1-Sep30	
ELSE IF	Oct1-Oct15	







The screenshot displays the 'Operations Tab' in the Reservoir Editor. The left sidebar shows a tree view of the dam's operations, with 'Rel-Oct' selected under the 'whitewater release' category. The main panel shows the configuration for this rule:

- Operates Release From: Bear Swamp
- Rule Name: Rel-Oct
- Function of: Date
- Limit Type: Mi... Interp.: ...

Below these settings is a table with two columns: 'Date' and 'Release (cfs)'. The first row shows '01Jan' with a release of '700.0'.

To the right of the main panel are two tables defining multipliers:

Time of Day	Multiplier
0000-0100	0.0
0100-0200	0.0
0200-0300	0.0
0300-0400	0.0
0400-0500	0.0
0500-0600	0.0
0600-0700	0.0
0700-0800	0.0
0800-0900	0.0
0900-1000	1.0
1000-1100	1.0
1100-1200	1.0
1200-1300	0.0
1300-1400	0.0
1400-1500	0.0
1500-1600	0.0
1600-1700	0.0
1700-1800	0.0
1800-1900	0.0
1900-2000	0.0
2000-2100	0.0
2100-2200	0.0
2200-2300	0.0
2300-2400	0.0

Day	Multiplier
Sun	1.00
Mon	0.00
Tues	0.00
Wed	1.00
Thurs	1.00
Fri	1.00
Sat	1.00

Figure 9: Reservoir Editor: Operations Tab – Existing Ops OpSet –Whitewater release

## Bellows Falls

### I. Overview

Bellows Falls dam is located on the mainstem Connecticut River in the towns of Rockingham, VT and Walpole, NH. It is owned and operated by TransCanada Hydro Northeast Inc. for hydropower generation on a run-of-river basis.

Figure 1 shows the location of Bellows Falls dam as it is represented in the HEC-ResSim model. Figure 2 shows a photo of Bellows Falls dam.

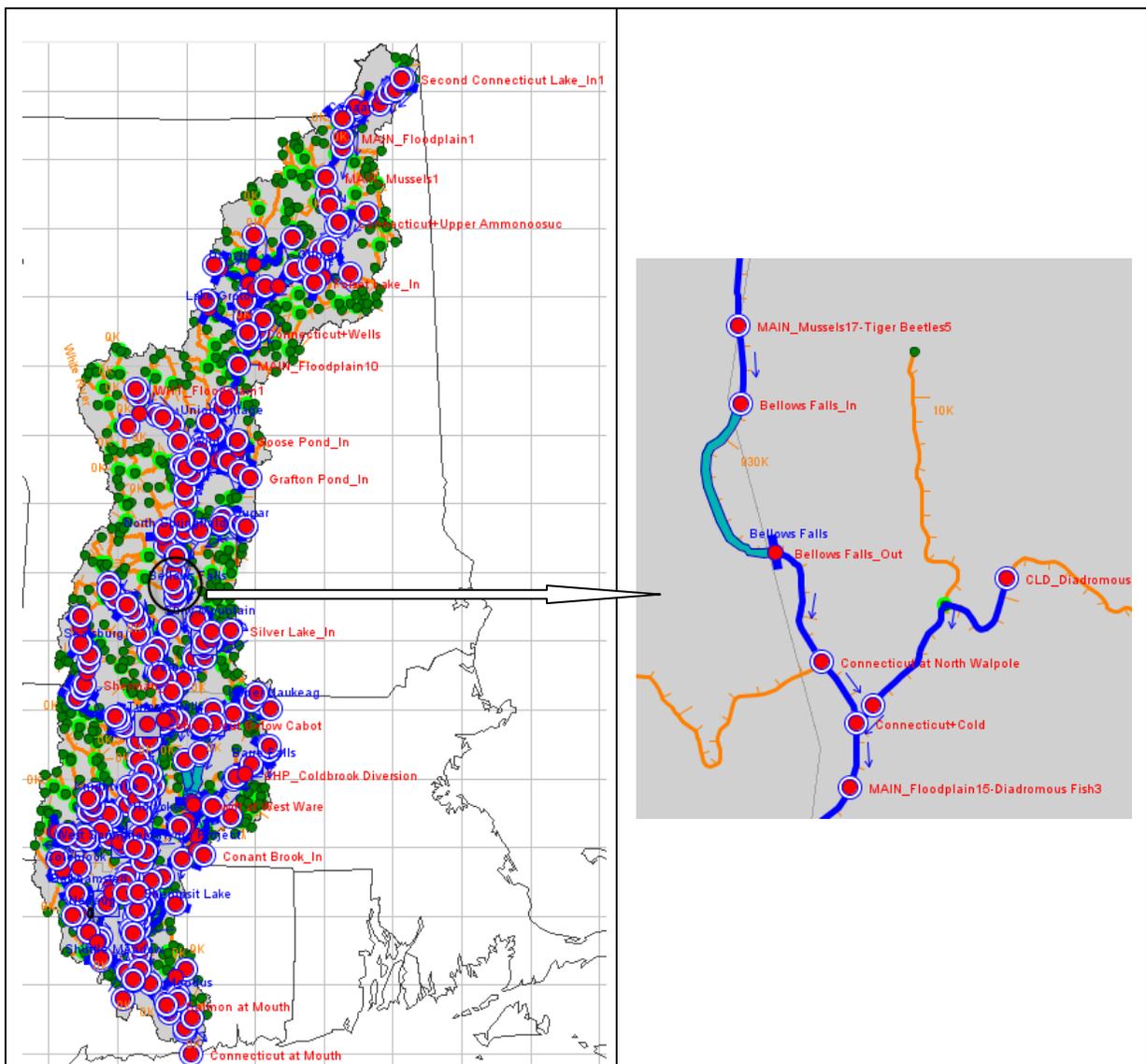


Figure 1: HEC-ResSim Map Display Showing Location of Bellows Falls dam



**Figure 2: Photo of Bellows Falls dam.**

## **II. Physical Characteristics**

The physical characteristics of the reservoir are separated between the Pool and the Dam in the HEC-ResSim model. The elevation-storage-area defines the pool as shown in Figure 3<sup>8</sup>. The dam consists of seven types of outlets: (1) controlled Roller gate, and (2) uncontrolled 121 ft Bay-w flashboards, (3) uncontrolled 100 ft Bay-w flashboards, (4) uncontrolled Stanchion-w flashboards, (5) controlled Fish Ladder, (6) Downstream Fish Passage, and (7) power plant as shown in Figure 4.

---

<sup>8</sup> Data provided by TransCanada

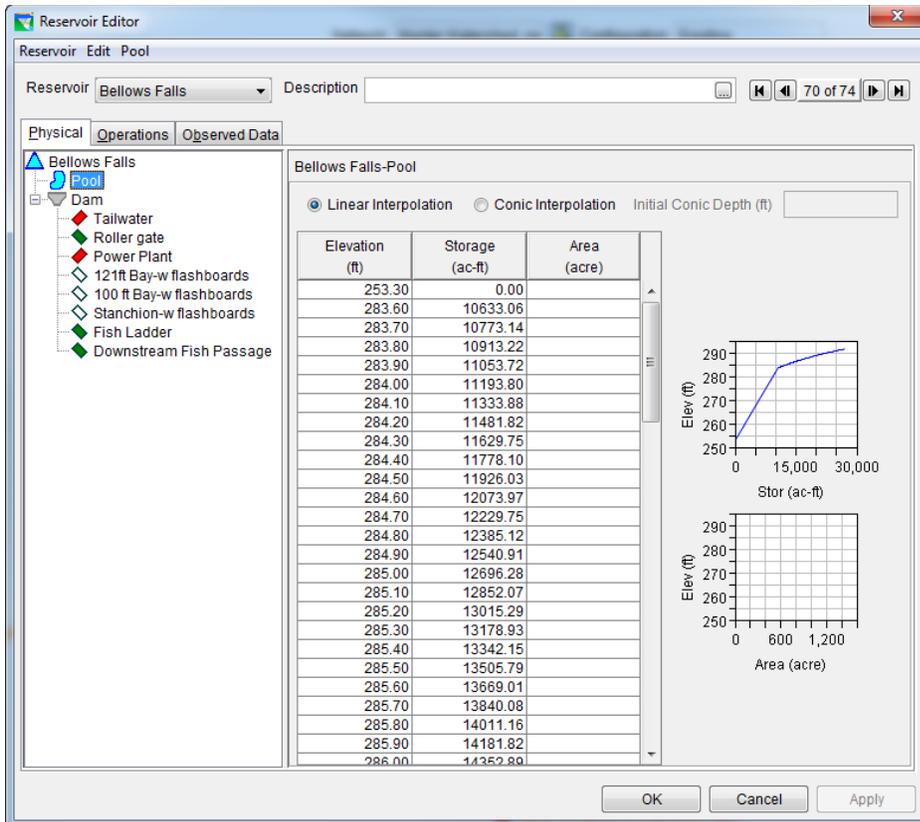


Figure 3: Reservoir Editor: Physical Tab -- Pool

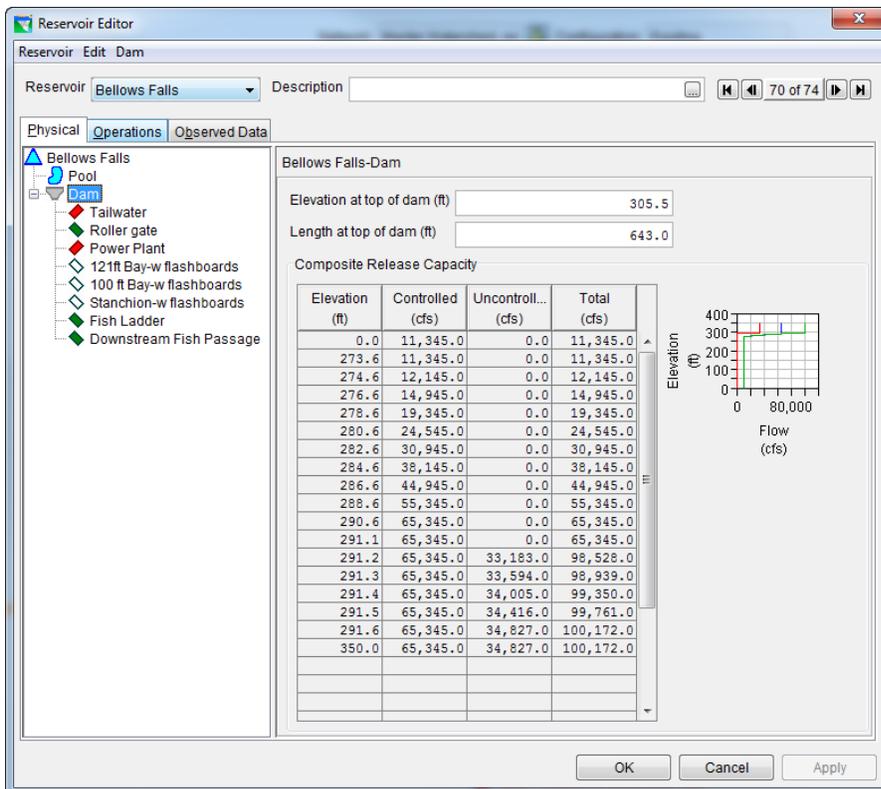


Figure 4: Reservoir Editor: Physical Tab -- Dam



Figure 6 shows a sequential release allocation approach specified for available outlets along Bellows Falls Dam. The available outlets are given an order of priority for release. The power plant gets the release first until it reaches release capacity. The Roller gate gets the remainder of the release until it reaches capacity. After the capacity through the Roller gate is reached, the remainder of the release goes through the Fish ladder gate and Downstream Fish Passage, respectively.

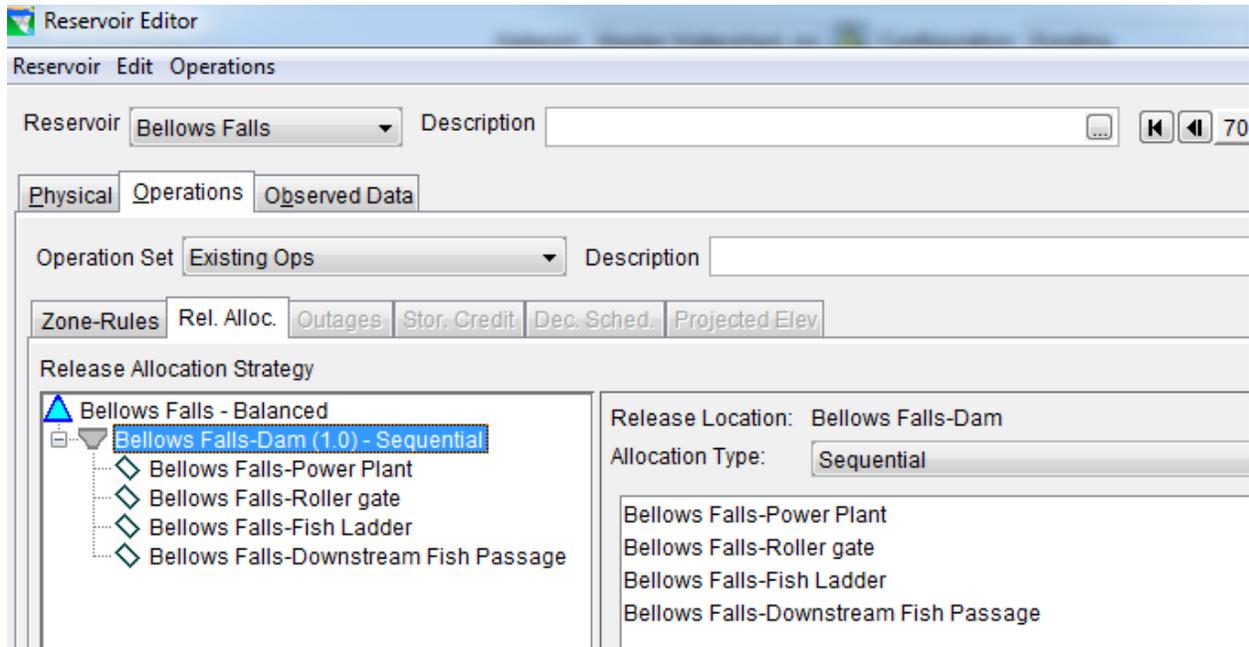


Figure 6: Reservoir Editor: Operations Tab – Existing Ops OpSet – Release Allocation

## B. Rule Illustrations

Figure 7 shows a set of operational rules specified for each zone that reflects the operation set named Existing Ops<sup>9</sup>.

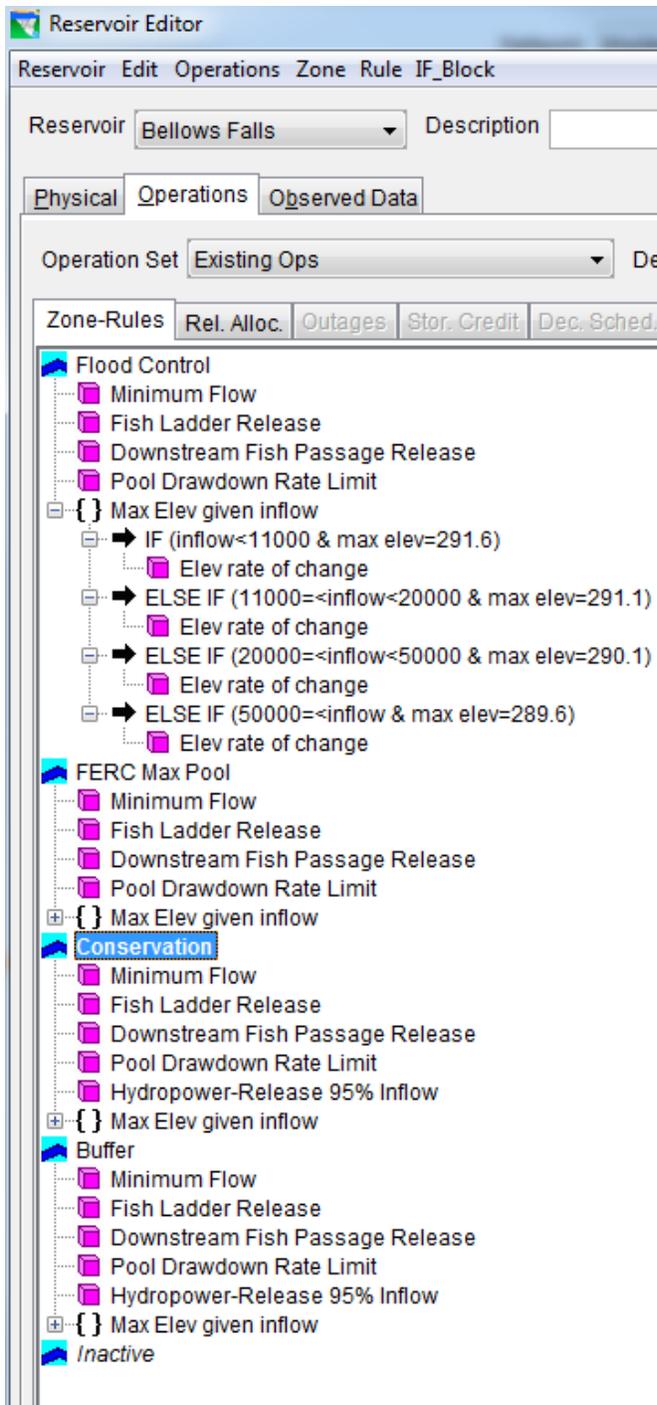


Figure 7: Reservoir Editor: Operations Tab – Existing Ops OpSet – Zones and Rules

<sup>9</sup> TransCanada. Connecticut River Operational Constraints. 2012.

## C. Rule Descriptions

### 1. Minimum Flow

Figure 8 shows the content of “Minimum Flow” rule. This rule represents the minimum release from dam as a function of flow.

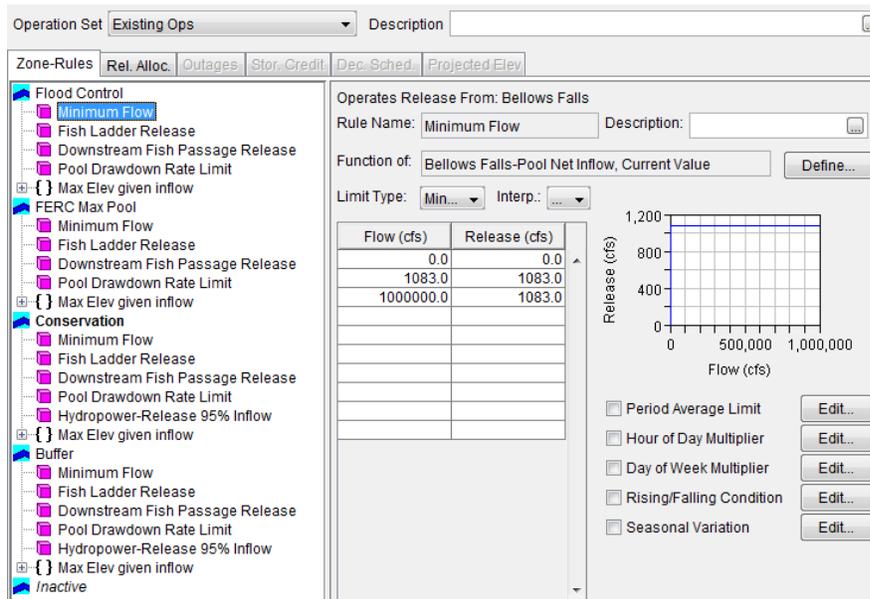


Figure 8: Reservoir Editor: Operations Tab – Existing Ops OpSet – Minimum Flow

### 2. Fish Ladder Release

Figure 9 shows the content of “Fish Ladder Release” rule. This rule shows the specified release from a fish ladder controlled outlet.

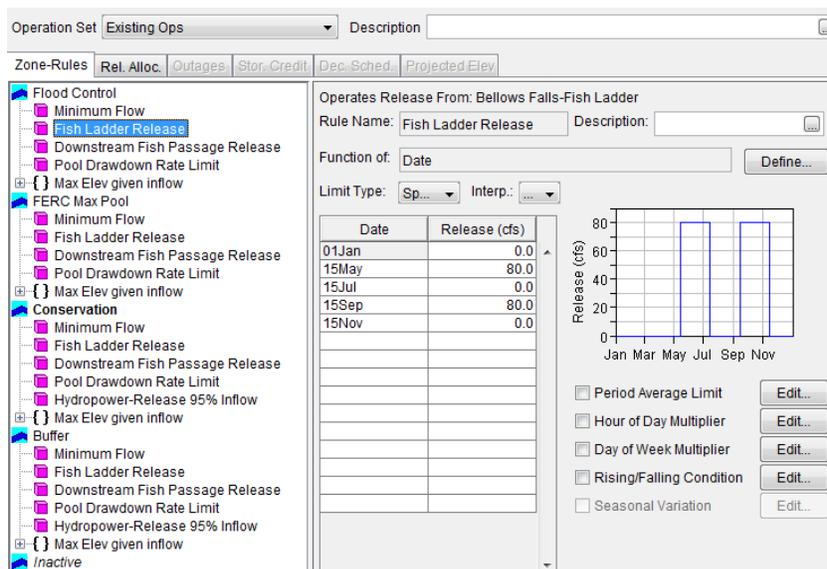


Figure 9: Reservoir Editor: Operations Tab – Existing Ops OpSet – Fish Ladder Release

### 3. Downstream Fish Passage Release

Figure 10 shows the content of “Downstream Fish Passage Release” rule. This rule shows the specified release from a Downstream Fish Passage controlled outlet.

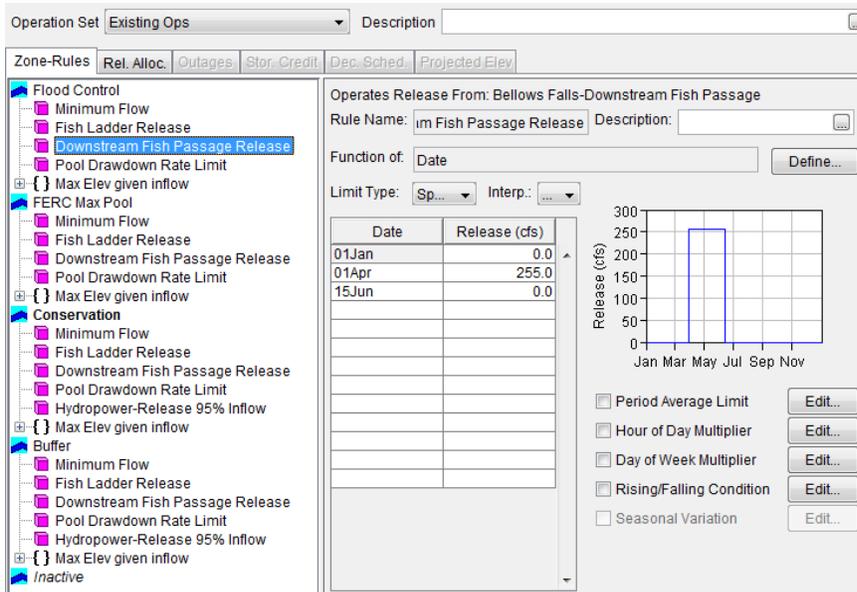


Figure 10: Reservoir Editor: Operations Tab – Existing Ops OpSet – Downstream Fish Passage Release

### 4. Pool Drawdown Rate Limit

Figure 11 shows the content of “Pool Drawdown Rate Limit” rule. This rule describes the maximum elevation rate of change.

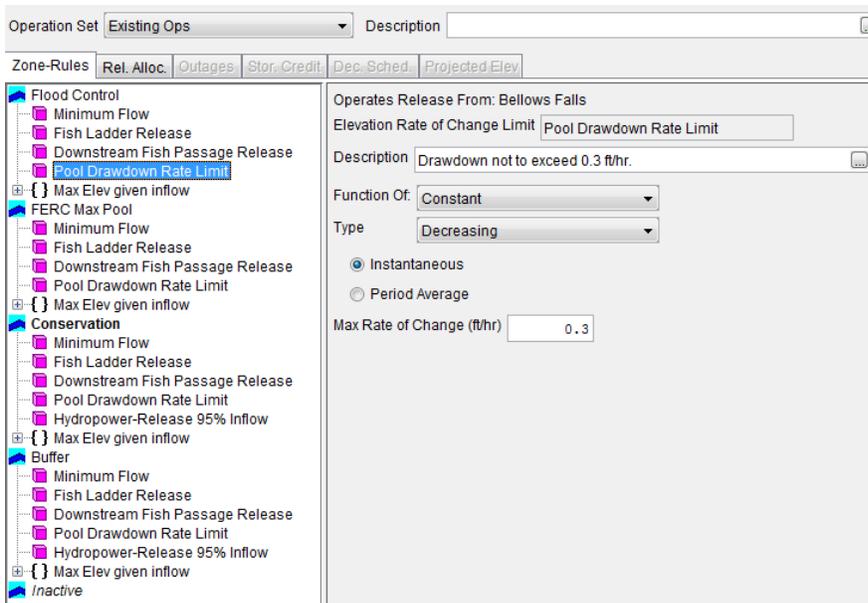


Figure 11: Reservoir Editor: Operations Tab – Existing Ops OpSet – Pool Drawdown Rate Limit

### 5. Max Elev given Inflow

Figure 12 shows the content of “Max Elev given Inlow” rule. This rule shows the maximum elevation rate of change for different range of inflow.

The figure consists of three screenshots from a software interface, likely for dam operations, showing the configuration of a rule named "Max Elev given Inflow".

**Top Screenshot: Rule Overview**

- Operation Set: Existing Ops
- Zone-Rules: Rel. Alloc., Outages, Stor. Credit, Dec. Sched., Projected Elev.
- Tree View: Flood Control > Max Elev given Inflow
- Operates Release From: Bellows Falls
- Name: Max Elev given Inflow
- Description: (empty)
- Summary Table:
 

Type	Name	Description
IF	inflow<11000 & max elev=291.6	
ELSE IF	11000=<inflow<20000 & max elev=291.1	
ELSE IF	20000=<inflow<50000 & max elev=290.1	
ELSE IF	50000=<inflow & max elev=289.6	

**Middle Screenshot: IF Conditional Configuration**

- Operates Release From: Bellows Falls
- IF Conditional: <11000 & max elev=291.6
- Description: (empty)
- Table:
 

	Value1		Value2
	Bellows Falls-Pool:Net Inflow	<	11000
AND	Bellows Falls-Pool:Net Inflow	>=	291.6
- Buttons: Add Cond., Del. Cond., Move Up, Move Down, Evaluate

**Bottom Screenshot: Elev rate of change Configuration**

- Operates Release From: Bellows Falls
- Elevation Rate of Change Limit: Elev rate of change
- Description: (empty)
- Function Of: Constant
- Type: Increasing
- Instantaneous:  (selected)
- Period Average:  (unselected)
- Max Rate of Change (ft/hr): 0.0

Operation Set: Existing Ops    Description:

Zone-Rules: Rel. Alloc. | Outages | Stor. Credit | Dec. Sched. | **Projected Elev.**

**Flood Control**

- Minimum Flow
- Fish Ladder Release
- Downstream Fish Passage Release
- Pool Drawdown Rate Limit
- Max Elev given inflow
  - IF (inflow<11000 & max elev=291.6)
    - Elev rate of change
  - ELSE IF (11000=<inflow<20000 & max elev=291.1)**
    - Elev rate of change
  - ELSE IF (20000=<inflow<50000 & max elev=290.1)
    - Elev rate of change
  - ELSE IF (50000=<inflow & max elev=289.6)
    - Elev rate of change

**FERC Max Pool**

- Minimum Flow
- Fish Ladder Release
- Downstream Fish Passage Release
- Pool Drawdown Rate Limit
- Max Elev given inflow

Operates Release From: Bellows Falls

ELSE IF Conditional: <20000 & max elev=291.1    Description:

	Value1		Value2
	Bellows Falls-Pool:Net Inflow	>=	11000
AND	Bellows Falls-Pool:Net Inflow	<	20000
AND	Bellows Falls-Pool:Elevation	>=	291.1

---

Operation Set: Existing Ops    Description:

Zone-Rules: Rel. Alloc. | Outages | Stor. Credit | Dec. Sched. | **Projected Elev.**

**Flood Control**

- Minimum Flow
- Fish Ladder Release
- Downstream Fish Passage Release
- Pool Drawdown Rate Limit
- Max Elev given inflow
  - IF (inflow<11000 & max elev=291.6)
    - Elev rate of change
  - ELSE IF (11000=<inflow<20000 & max elev=291.1)
    - Elev rate of change**
  - ELSE IF (20000=<inflow<50000 & max elev=290.1)
    - Elev rate of change
  - ELSE IF (50000=<inflow & max elev=289.6)
    - Elev rate of change

**FERC Max Pool**

- Minimum Flow
- Fish Ladder Release
- Downstream Fish Passage Release
- Pool Drawdown Rate Limit
- Max Elev given inflow

Operates Release From: Bellows Falls

Elevation Rate of Change Limit:

Description:

Function Of:

Type:

Instantaneous

Period Average

Max Rate of Change (ft/hr):

---

Operation Set: Existing Ops    Description:

Zone-Rules: Rel. Alloc. | Outages | Stor. Credit | Dec. Sched. | **Projected Elev.**

**Flood Control**

- Minimum Flow
- Fish Ladder Release
- Downstream Fish Passage Release
- Pool Drawdown Rate Limit
- Max Elev given inflow
  - IF (inflow<11000 & max elev=291.6)
    - Elev rate of change
  - ELSE IF (11000=<inflow<20000 & max elev=291.1)
    - Elev rate of change
  - ELSE IF (20000=<inflow<50000 & max elev=290.1)**
    - Elev rate of change
  - ELSE IF (50000=<inflow & max elev=289.6)
    - Elev rate of change

**FERC Max Pool**

- Minimum Flow
- Fish Ladder Release
- Downstream Fish Passage Release
- Pool Drawdown Rate Limit
- Max Elev given inflow

Operates Release From: Bellows Falls

ELSE IF Conditional: <50000 & max elev=290.1    Description:

	Value1		Value2
	Bellows Falls-Pool:Net Inflow	>=	20000
AND	Bellows Falls-Pool:Net Inflow	<	50000
AND	Bellows Falls-Pool:Elevation	>=	290.1

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The figure consists of three vertically stacked screenshots of the Reservoir Editor's Operations Tab, showing the configuration for the 'Max Elev given Inflow' rule. Each screenshot has a 'Zone-Rules' pane on the left and a configuration pane on the right.

**Top Screenshot:** The 'Zone-Rules' pane shows the 'Max Elev given inflow' rule selected. The configuration pane shows 'Operates Release From: Bellows Falls', 'Elevation Rate of Change Limit' set to 'Elev rate of change', 'Function Of' set to 'Constant', and 'Type' set to 'Increasing'. The 'Max Rate of Change (ft/hr)' is set to 0.0.

**Middle Screenshot:** The 'Zone-Rules' pane shows the 'Max Elev given inflow' rule selected. The configuration pane shows 'Operates Release From: Bellows Falls' and 'ELSE IF Conditional' set to '<=inflow & max elev=289.6'. A table below shows the conditional logic:

	Value1		Value2
	Bellows Falls-Pool:Net Inflow	>=	50000
AND	Bellows Falls-Pool:Elevation	>=	289.6

Buttons for 'Add Cond.', 'Del. Cond.', 'Move Up', 'Move Down', and 'Evaluate' are visible on the right.

**Bottom Screenshot:** The 'Zone-Rules' pane shows the 'Max Elev given inflow' rule selected. The configuration pane shows 'Operates Release From: Bellows Falls', 'Elevation Rate of Change Limit' set to 'Elev rate of change', 'Function Of' set to 'Constant', and 'Type' set to 'Increasing'. The 'Max Rate of Change (ft/hr)' is set to 0.0.

Figure 12: Reservoir Editor: Operations Tab – Existing Ops OpSet – Max Elev given Inflow

### 6. Hydropower-Release 95% Inflow

Figure 13 shows the content of “Hydropower-Release 95% Inflow” rule. This rule releases 95% of inflow through power plant as per the run-of-river modeling strategy.

The screenshot displays the 'Operations Tab' in the Reservoir Editor. The 'Existing Ops' set is selected. The 'Hydropower-Release 95% Inflow' rule is highlighted in the tree view. The main configuration area shows the following details:

- Operates Release From:** Bellows Falls-Power Plant
- Rule Name:** lower-Release 95% Inflow
- Function of:** Bellows Falls-Pool Net Inflow, Current Value
- Limit Type:** Mini... (dropdown)
- Interp.:** ... (dropdown)

A table defines the release limits:

Flow (cfs)	Release (cfs)
0.0	0.0
100000.0	95000.0

To the right of the table is a graph plotting Release (cfs) on the y-axis (0 to 100,000) against Flow (cfs) on the x-axis (0 to 100,000). A blue line shows a linear relationship from (0,0) to (100,000, 95,000).

Additional configuration options on the right include:

- Period Average Limit (Edit...)
- Hour of Day Multiplier (Edit...)
- Day of Week Multiplier (Edit...)
- Rising/Falling Condition (Edit...)
- Seasonal Variation (Edit...)

Figure 13: Reservoir Editor: Operations Tab – Existing Ops OpSet – Hydropower-Release 95% Inflow

# Bickford

## I. Overview

Bickford dam is a dam on the Ware River by Worcester, MA. Construction of the reservoir was completed in 1970 and the dam is owned by the City of Fitchburg, which uses it for water supply for the city. .

Figure 1 shows the location of Bickford Dam as it is represented in the HEC-ResSim model. Figure 2 shows a view from the dam.

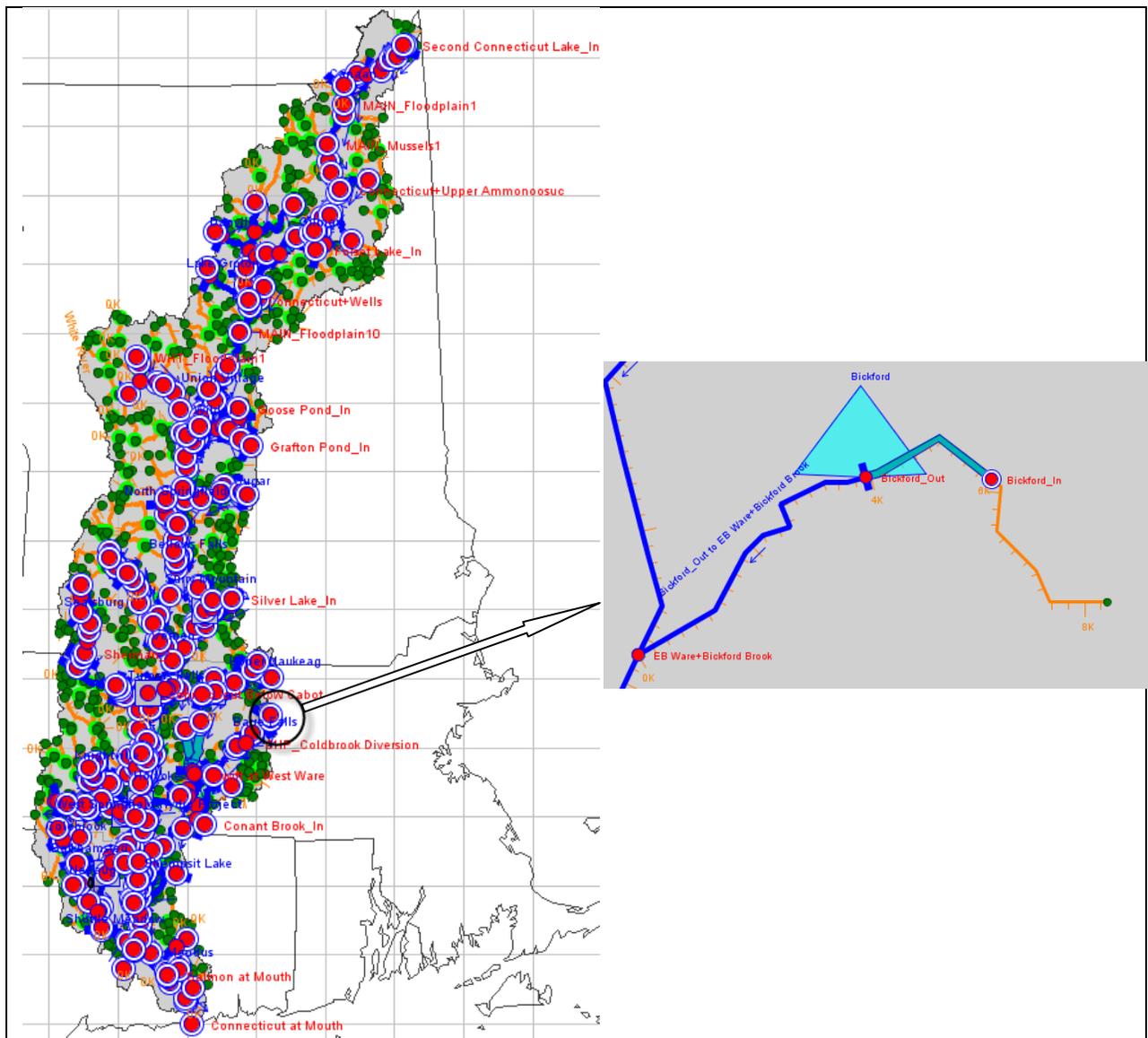


Figure 1: HEC-ResSim Map Display Showing Location of Bickford



**Figure 2: View from Bickford Dam**

## **II. Physical Characteristics**

The physical characteristics of the reservoir are separated between the Pool and the Dam in the HEC-ResSim model. The elevation-storage-area defines the pool as shown in Figure 3<sup>10</sup>. The dam consists of a controlled outlet and an uncontrolled spillway as shown in Figure 4.

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<sup>10</sup> Bickford Dam Phase 1 Report: 1980



### III. Operations

#### A. Operation Set

Zones are used to define the operational storage in the reservoir to determine the reservoir release through analysis of the rules contained within each zone. Figure 5 shows the definition of Bickford’s “Existing Ops” operational zones, which consist of the zones Flood Control (1051.2 ft), Conservation (1045 ft), and Inactive (1000 ft)<sup>1</sup>.

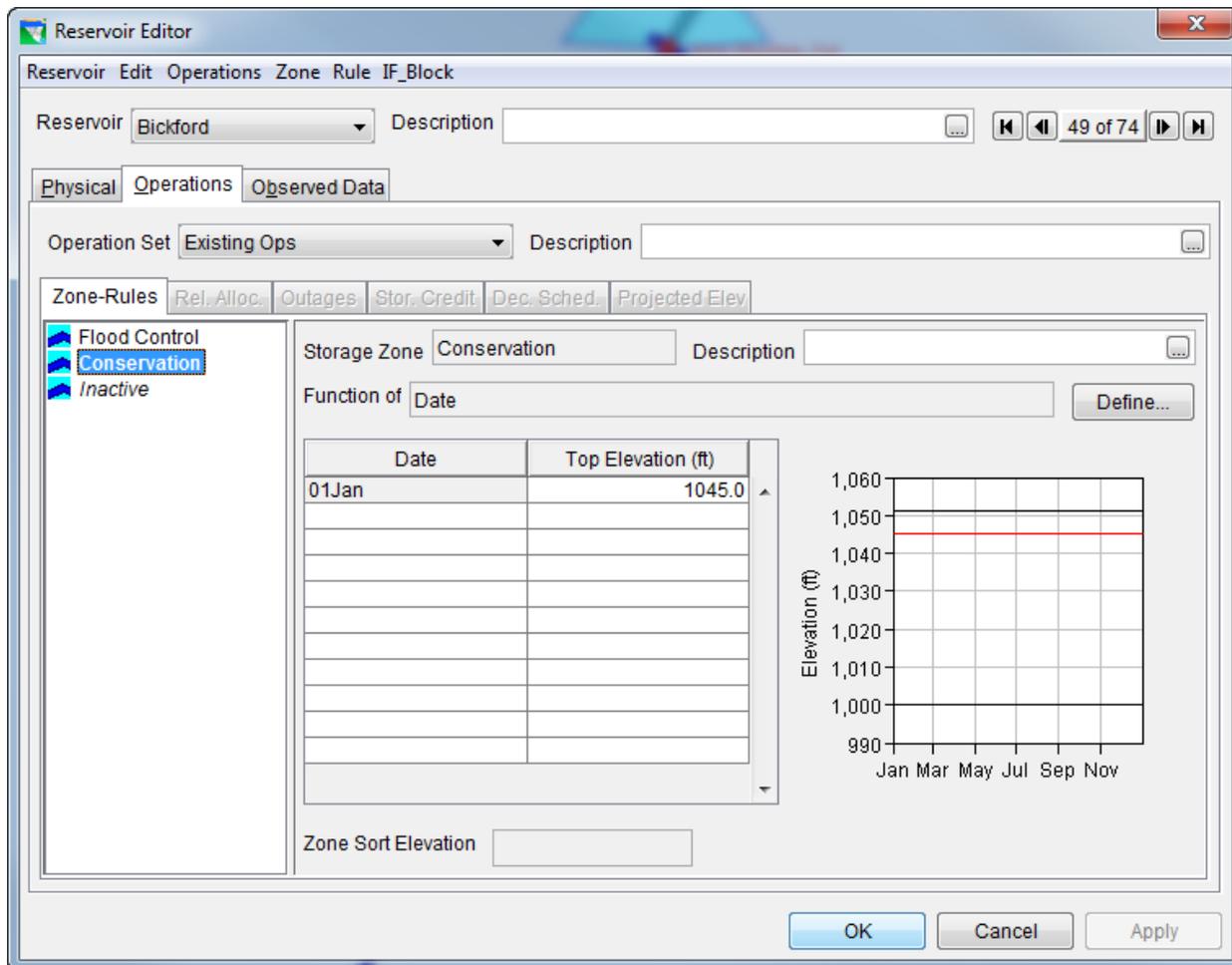


Figure 5: Reservoir Editor -- Operations Tab – Existing Ops OpSet

#### B. Rule Illustrations

The operation set for Bickford has no rules of operation making it a flow through reservoir. The pool elevation will remain at the top of conservation unless the inflow exceeds the total release capacity. There is a water supply timeseries for Bickford that is described in the water supply section of the report.

# Birch Hill

## I. Overview

Birch Hill is a dam on the Millers River upstream of Athol. Constructed in 1941 by the US Army Corps of Engineers, it is still owned and operated by the Corps. It is primarily used for flood control but is also used for recreation.

Figure 1 shows the location of Birch Hill Dam as it is represented in the HEC-ResSim model. Figure 2 shows a photo of the dam.

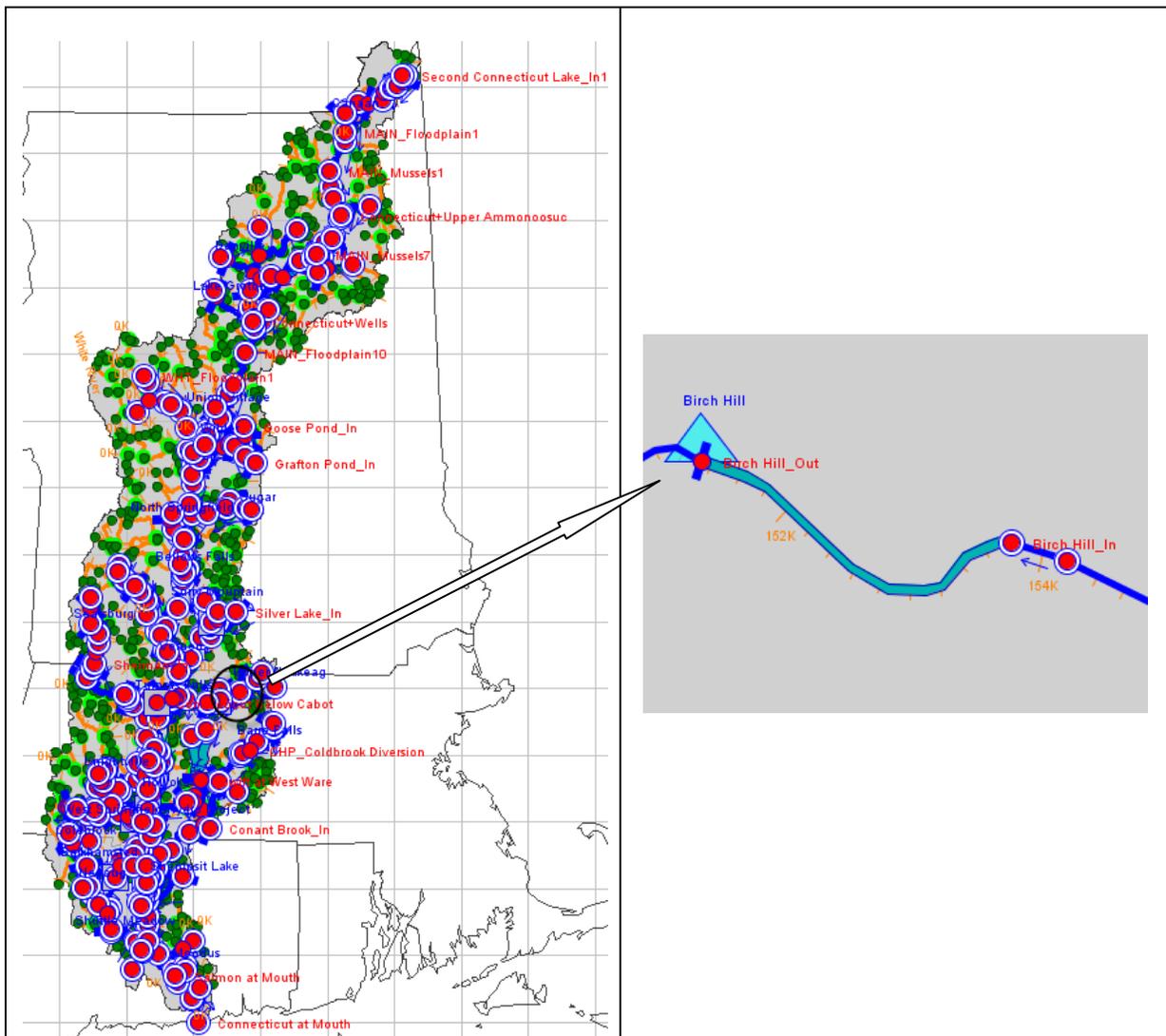


Figure 1: HEC-ResSim Map Display Showing Location of Birch Hill dam



Figure 2: Photo of Birch Hill dam

## II. Physical Characteristics

The physical characteristics of the reservoir are separated between the Pool and the Dam in the HEC-ResSim model. The elevation-storage-area defines the pool as shown in Figure 3. The dam consists of two types of outlets: (1) controlled slide gates, and (2) uncontrolled spillway, as shown in Figure 4. All physical and operations data were provided by US Army Corps New England District, through both a previously created ResSim model and the Reservoir Regulation Team website<sup>11</sup>.

<sup>11</sup> [http://rsgisias.crrel.usace.army.mil/nae/cwms\\_map.map\\_index](http://rsgisias.crrel.usace.army.mil/nae/cwms_map.map_index)

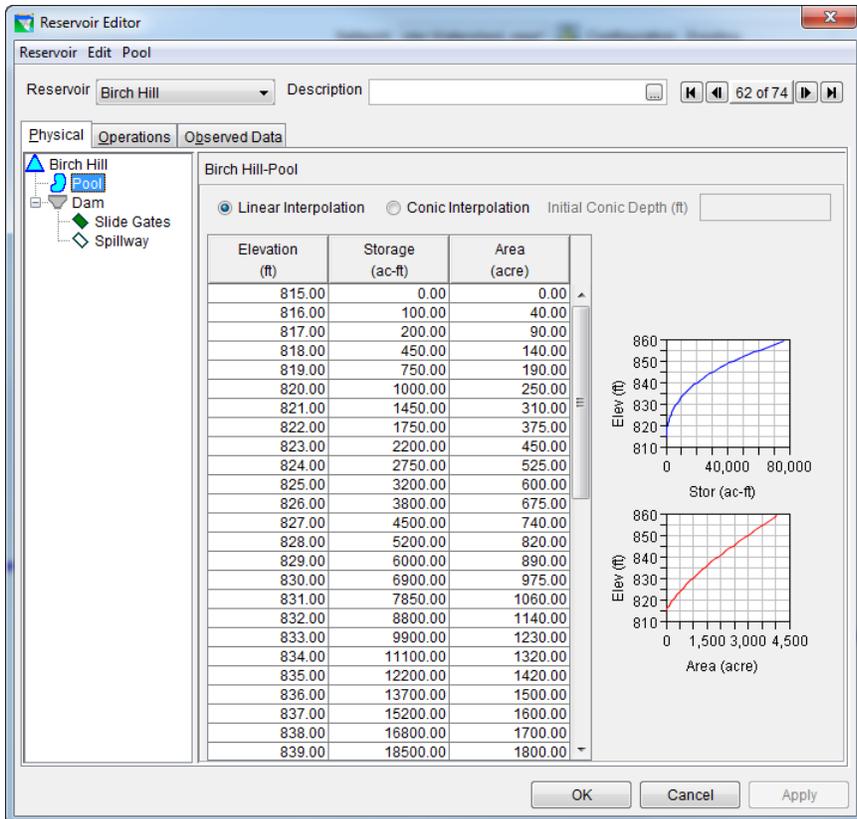


Figure 3: Reservoir Editor: Physical Tab -- Pool

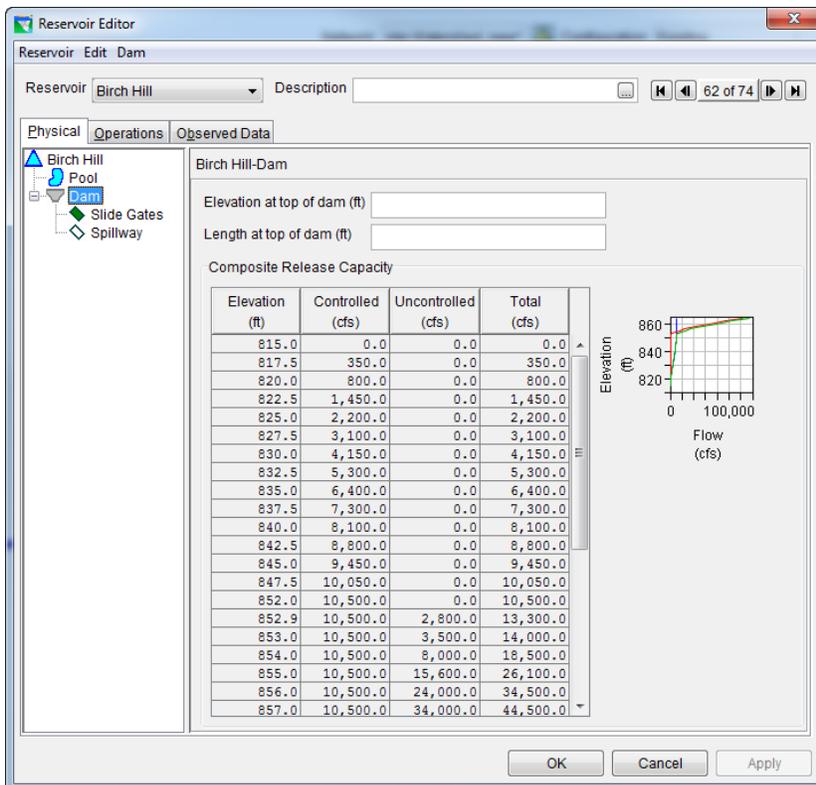


Figure 4: Reservoir Editor: Physical Tab -- Dam



## B. Rule Illustrations

Figure 6 shows a set of operational rules specified for each zone that reflects the operation set named ExistingOps. As described in the Simulation/Verification section of the report, adjustments were made to the operations to closer match gauge data.

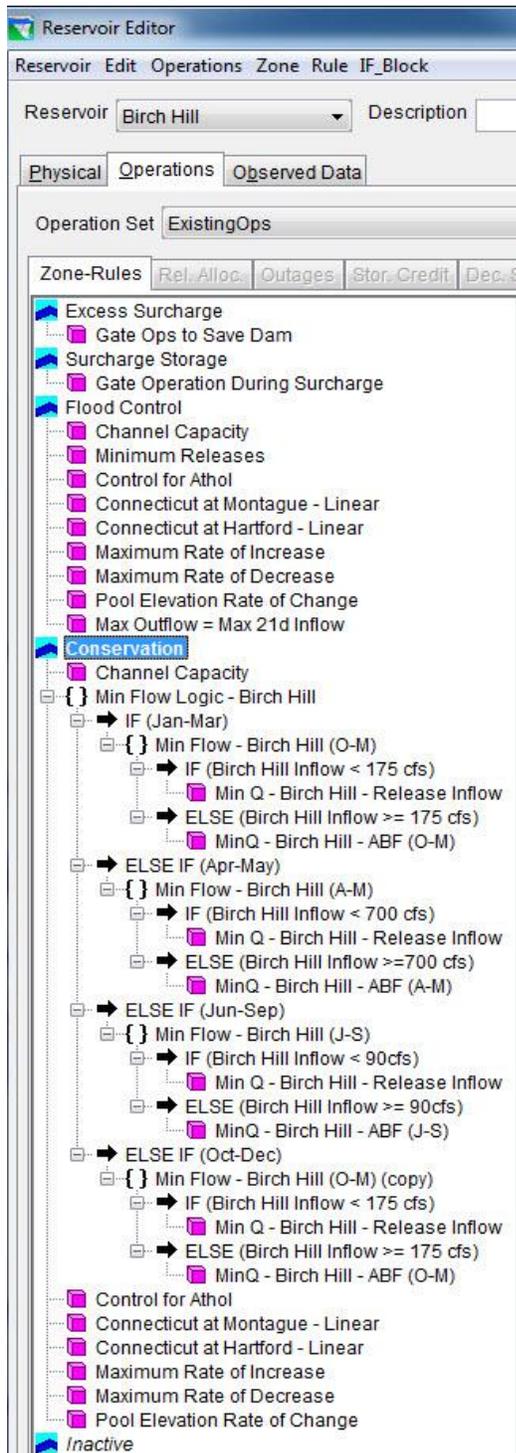


Figure 6: Reservoir Editor: Operations Tab – Existing Ops OpSet – Zones and Rules

## C. Rule Descriptions

### 1. Gate Ops to Save Dam

Figure 7 shows the content of “Gate Ops to Save Dam” rule. This rule represents the maximum allowable release from Slide gates when the pool is in Excess Surcharge zone as a function of pool elevation.

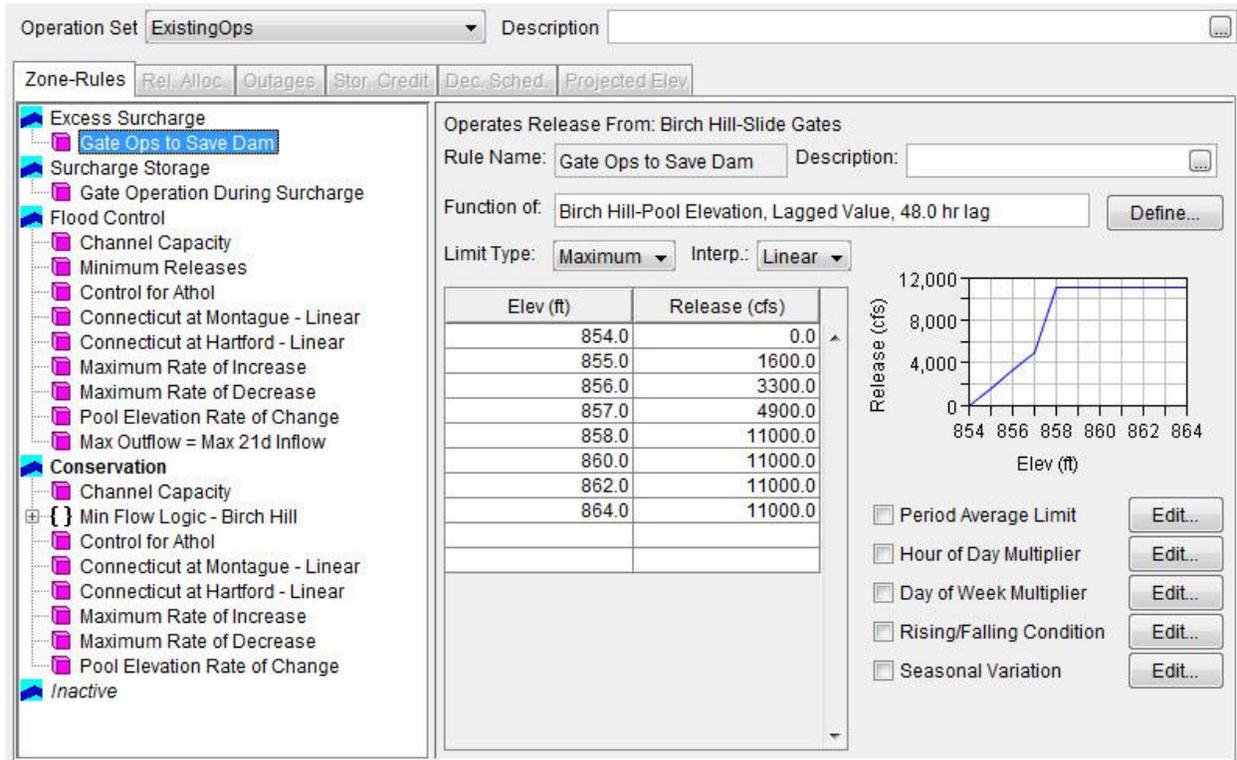


Figure 7: Reservoir Editor: Operations Tab – Existing Ops OpSet –Gate Ops to Save Dam

## 2. Gate Operation During Surcharge

Figure 8 shows the content of “Gate Operation During Surcharge” rule. This rule represents the maximum allowable release from Birch Hill when the pool is in surcharge Storage zone as a function of pool elevation.

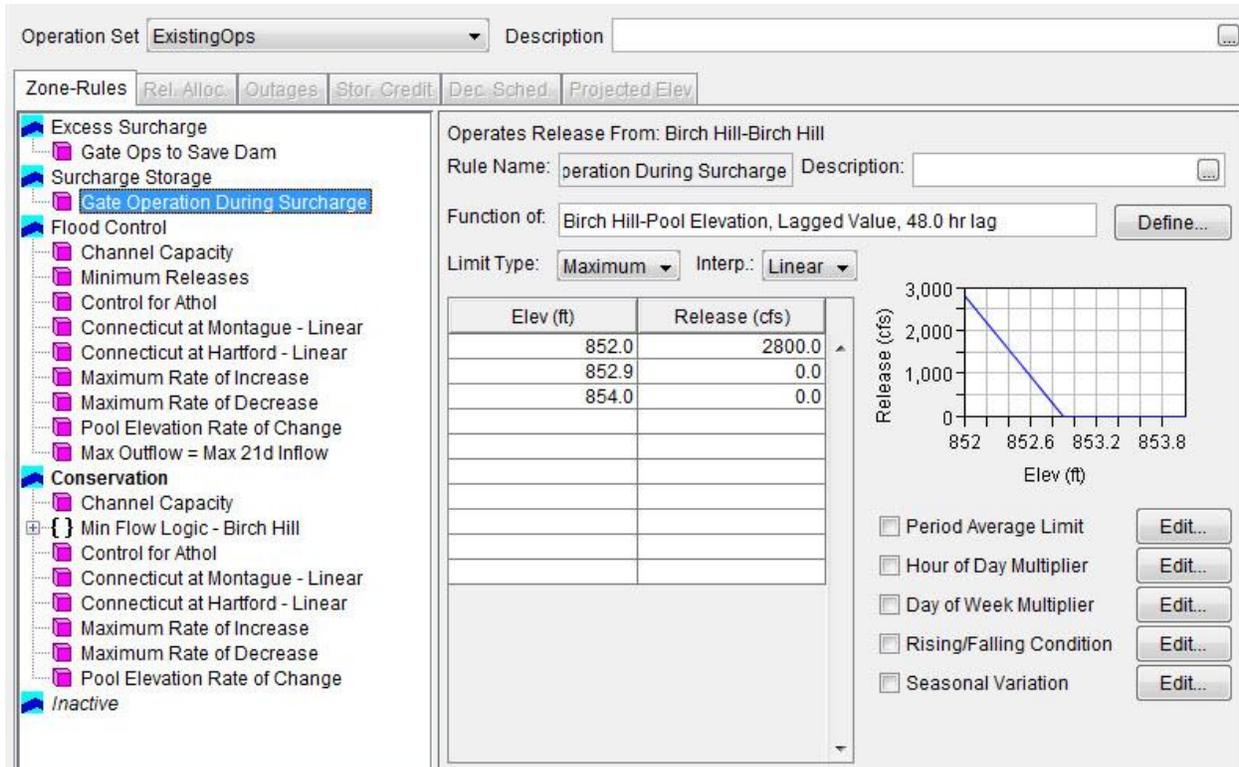


Figure 8: Reservoir Editor: Operations Tab – Existing Ops OpSet –Gate Operation During Surcharge





### 5. Control for Athol

Figure 11 shows the content of “Control for Athol” rule. This rule represents the maximum release from the dam as a function of stage at Athol over the previous four days. This rule was taken from a previously created ResSim model of Birch Hill dam.

Operation Set: ExistingOps    Description: [ ]

Zone-Rules: Rel. Alloc. | Outages | Stor. Credit | Dec. Sched. | Projected Elev.

Operates Release From: Birch Hill-Slide Gates

Rule Name: Control for Athol    Description: [ ]

Function of: Ilers at Athol Stage, Period Average, 24.0 hr lag, 72.0 hr period    Define...

Limit Type: Maximum    Interp.: Linear

Stage (ft)	Release (cfs)
0.0	2800.0
2.0	1400.0
3.0	90.0
10.0	90.0

Release (cfs) vs Stage (ft) graph showing a linear decrease from 2800 cfs at 0 ft to 90 cfs at 3 ft, then constant at 90 cfs up to 10 ft.

Period Average Limit    Edit...  
 Hour of Day Multiplier    Edit...  
 Day of Week Multiplier    Edit...  
 Rising/Falling Condition    Edit...  
 Seasonal Variation    Edit...

Figure 11: Reservoir Editor: Operations Tab – Existing Ops OpSet –Control for Athol

### 6. Connecticut at Montague – Linear

Figure 12 shows the content of “Connecticut at Montague-Linear” rule. This rule represents the maximum allowable release from the dam as a function of the previous day stage at Montague. The previous day stage was used to account for the delay that occurs between the stage exceeding the specified target and the change in operations at the flood control dams that occurs in reality.

Operation Set: ExistingOps Description: [ ]

Zone-Rules: Rel. Alloc. Outages Stor. Credit Dec. Sched. Projected Elev

- Excess Surcharge
  - Gate Ops to Save Dam
- Surcharge Storage
  - Gate Operation During Surcharge
- Flood Control
  - Channel Capacity
  - Minimum Releases
  - Control for Athol
  - Connecticut at Montague - Linear**
  - Connecticut at Hartford - Linear
  - Maximum Rate of Increase
  - Maximum Rate of Decrease
  - Pool Elevation Rate of Change
  - Max Outflow = Max 21d Inflow
- Conservation
  - Channel Capacity
  - Min Flow Logic - Birch Hill
  - Control for Athol
  - Connecticut at Montague - Linear
  - Connecticut at Hartford - Linear
  - Maximum Rate of Increase
  - Maximum Rate of Decrease
  - Pool Elevation Rate of Change
- Inactive

Operates Release From: Birch Hill

Rule Name: cticut at Montague - Linear Description: [ ]

Function of: Connecticut at Montague Stage, Previous Value Define...

Limit Type: Maximum Interp.: Linear

Stage (ft)	Release (cfs)
0.0	2800.0
26.0	2800.0
27.0	2240.0
28.0	1680.0
29.0	1120.0
30.0	560.0
31.0	0.0
50.0	0.0

Graph: Release (cfs) vs Stage (ft). The graph shows a horizontal line at 2800 cfs from 0 to 26 ft, then a linear decrease to 0 cfs at 50 ft.

Options:
 

- Period Average Limit Edit...
- Hour of Day Multiplier Edit...
- Day of Week Multiplier Edit...
- Rising/Falling Condition Edit...
- Seasonal Variation Edit...

Figure 12: Reservoir Editor: Operations Tab – Existing Ops OpSet – Connecticut at Montague – Linear

### 7. Connecticut at Hartford – Linear

Figure 13 shows the content of “Connecticut at Montague-Linear” rule. This rule represents the maximum allowable release from dam as a function of previous day stage at Hartford. The previous day stage was used to account for the delay that occurs between the stage exceeding the specified target and the change in operations at the flood control dams that occurs in reality.

The screenshot shows the 'Operations Tab' for an 'ExistingOps' set. The 'Zone-Rules' tree on the left has 'Connecticut at Hartford - Linear' selected. The main panel shows the rule configuration:

- Operates Release From: Birch Hill
- Rule Name: Connecticut at Hartford - Linear
- Function of: Connecticut at Hartford Stage, Previous Value
- Limit Type: Maximum
- Interp.: Linear

Stage (ft)	Release (cfs)
0.0	2800.0
18.0	2800.0
19.0	2240.0
20.0	1680.0
21.0	1120.0
22.0	560.0
23.0	0.0
50.0	0.0

The graph on the right plots Release (cfs) against Stage (ft), showing a constant release of 2800 cfs until 18 ft, followed by a linear decrease to 0 cfs at 23 ft.

Additional options on the right include checkboxes for Period Average Limit, Hour of Day Multiplier, Day of Week Multiplier, Rising/Falling Condition, and Seasonal Variation, each with an 'Edit...' button.

Figure 13: Reservoir Editor: Operations Tab – Existing Ops OpSet – Connecticut at Hartford - Linear

### 8. Maximum Rate of Increase

Figure 14 shows the content of “Maximum Rate of Increase” rule. This rule shows the increasing maximum allowable release rate of change rule as a function of release from Birch Hill dam.

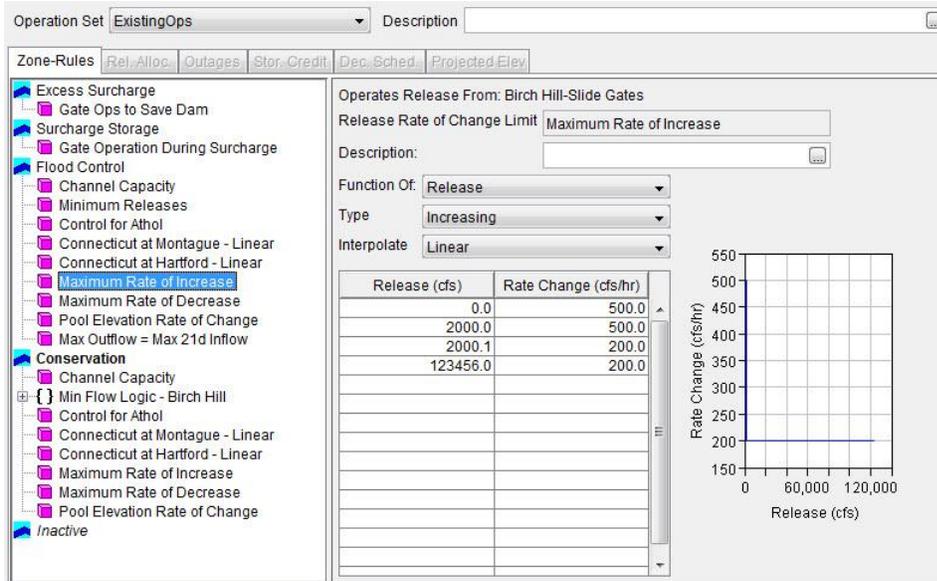


Figure 14: Reservoir Editor: Operations Tab – Existing Ops OpSet – Maximum Rate of Increase

### 9. Maximum Rate of Decrease

Figure 15 shows the content of “Maximum Rate of Decrease” rule. This rule shows the maximum allowable decreasing release rate of change rule.

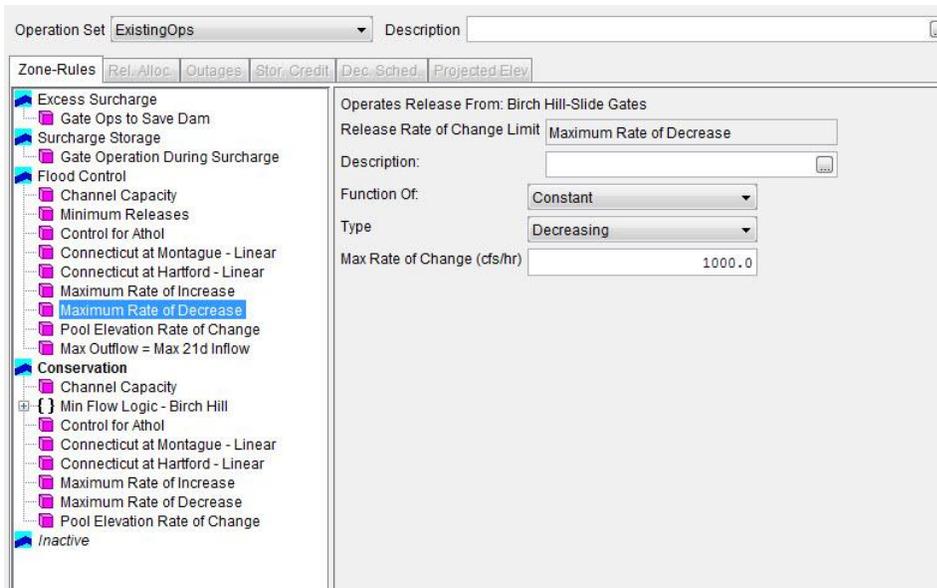


Figure 15: Reservoir Editor: Operations Tab – Existing Ops OpSet – Maximum Rate of Decrease

### 10. Max Pool Elev ROC

Figure 16 shows the content of “Max Pool Elev ROC” rule. This rule shows the maximum allowable decreasing pool elevation rate of change.

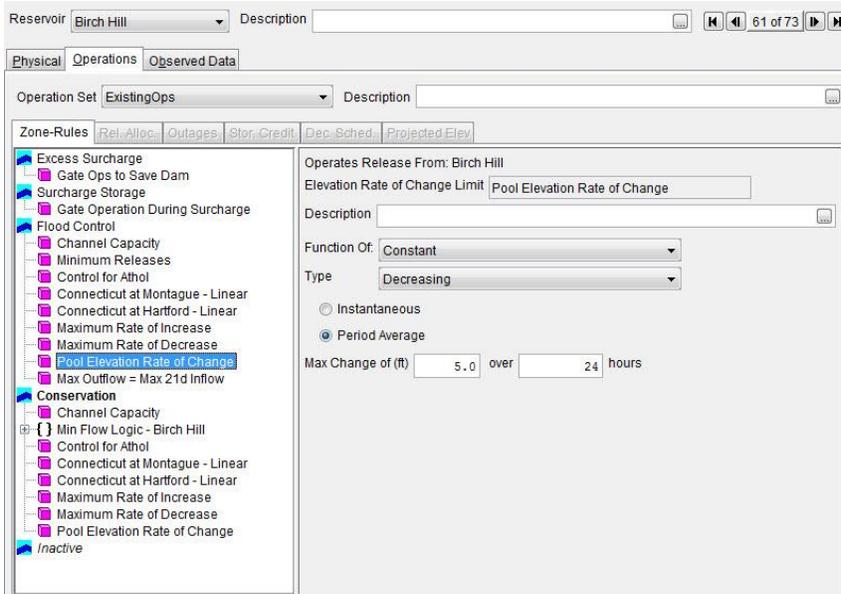


Figure 16: Reservoir Editor: Operations Tab – Existing Ops OpSet – Pool Elevation Rate of Change

### 11. Max Outflow equals 21 day max inflow

Figure 17 shows the content of “Max Outflow equals 21 day max inflow” rule. This rule represents the maximum release from dam as a function of the previous 3 weeks of inflow.

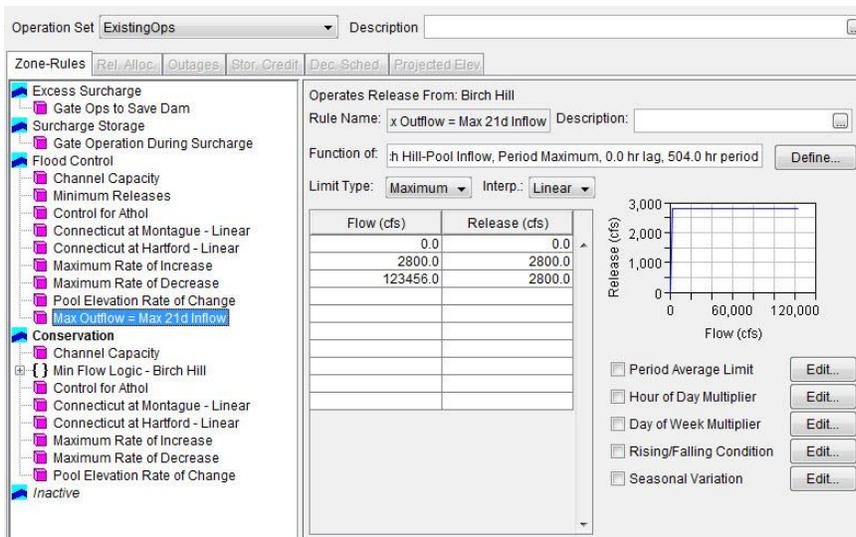


Figure 17: Reservoir Editor: Operations Tab – Existing Ops OpSet – Max Outflow equals 21 day max inflow

### 12. Min flow Logic-Birch Hill

Figure 17 shows the content of “Min Flow Logic-Birch Hill” rule. This rule shows the minimum release from dam as a function of inflow for different months.

The screenshot displays the 'Operations Tab' in the Reservoir Editor. The 'Operation Set' is set to 'ExistingOps'. The 'Zone-Rules' section is active, showing a tree view of the 'Min Flow Logic - Birch Hill' rule. The rule is structured as follows:

- IF (Jan-Mar)
  - Min Flow - Birch Hill (O-M)
    - IF (Birch Hill Inflow < 175 cfs)
      - Min Q - Birch Hill - Release Inflow
    - ELSE (Birch Hill Inflow >= 175 cfs)
      - Min Q - Birch Hill - ABF (O-M)
  - ELSE IF (Apr-May)
    - Min Flow - Birch Hill (A-M)
      - IF (Birch Hill Inflow < 700 cfs)
        - Min Q - Birch Hill - Release Inflow
      - ELSE (Birch Hill Inflow >= 700 cfs)
        - Min Q - Birch Hill - ABF (A-M)
    - ELSE IF (Jun-Sep)
      - Min Flow - Birch Hill (J-S)
        - IF (Birch Hill Inflow < 90cfs)
          - Min Q - Birch Hill - Release Inflow
        - ELSE (Birch Hill Inflow >= 90cfs)
          - Min Q - Birch Hill - ABF (J-S)
      - ELSE IF (Oct-Dec)
        - Min Flow - Birch Hill (O-M) (copy)
          - IF (Birch Hill Inflow < 175 cfs)
            - Min Q - Birch Hill - Release Inflow
          - ELSE (Birch Hill Inflow >= 175 cfs)
            - Min Q - Birch Hill - ABF (O-M)

Figure 17: Reservoir Editor: Operations Tab – Existing Ops OpSet –Min Flow Logic-Birch Hill

## Borden Brook

### I. Overview

Borden Brook dam is located in Granville, MA and feeds into the Westfield River. It is owned by the City of Springfield and is used for drinking water supply and hydroelectric power generation. Construction of the dam was completed in 1909.

Figure 1 shows the location of Borden Brook Dam as it is represented in the HEC-ResSim model. Figure 2 shows an aerial view of the reservoir.

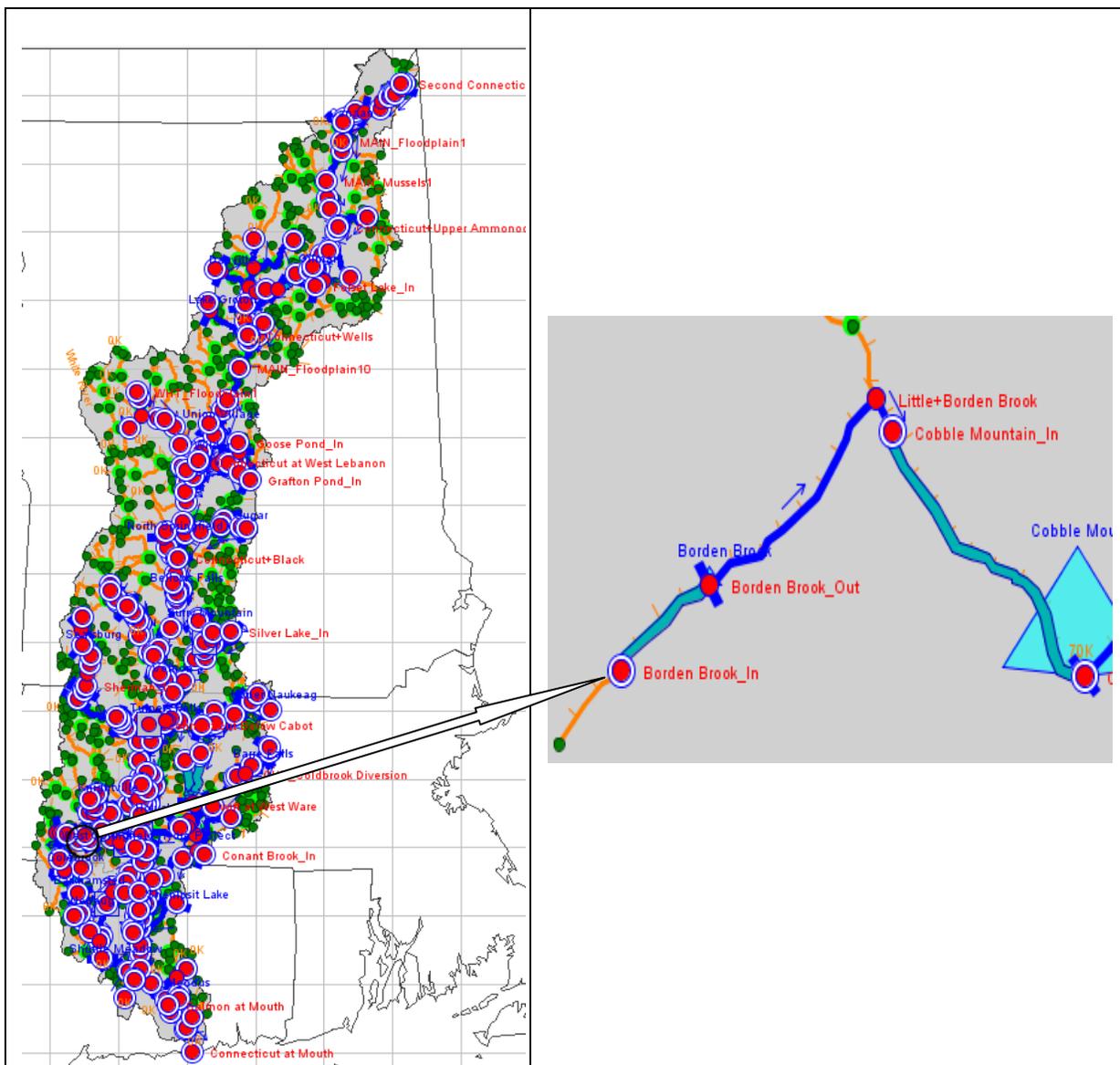


Figure 1: HEC-ResSim Map Display Showing Location of Borden Brook



Figure 2: Aerial photo of Borden Brook Reservoir

## II. Physical Characteristics

The physical characteristics of the reservoir are separated between the Pool and the Dam in the HEC-ResSim model. The elevation-storage-area defines the pool as shown in Figure 3<sup>12</sup>. The dam consists of four types of outlets: (1) uncontrolled spillway, (2) controlled Upper 24-inch outlet, (3) controlled Lower 24-inch outlet, and (4) controlled Low-Level 36-inch outlet as shown in Figure 4.

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<sup>12</sup> Springfield Water and Sewer Commission. Water Supply System History and Statistics. 1999





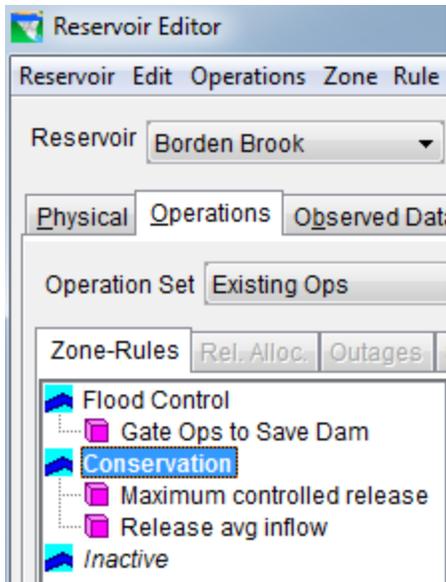


Figure 6: Reservoir Editor -- Operations Tab – Existing Ops OpSet – Zones and Rules

### C. Rule Descriptions

#### 1. Gate Ops to save Dam

Figure 7 shows the content of “Gate Ops to save Dam” rule. This rule increases the minimum release from Dam as a function of pool elevation.

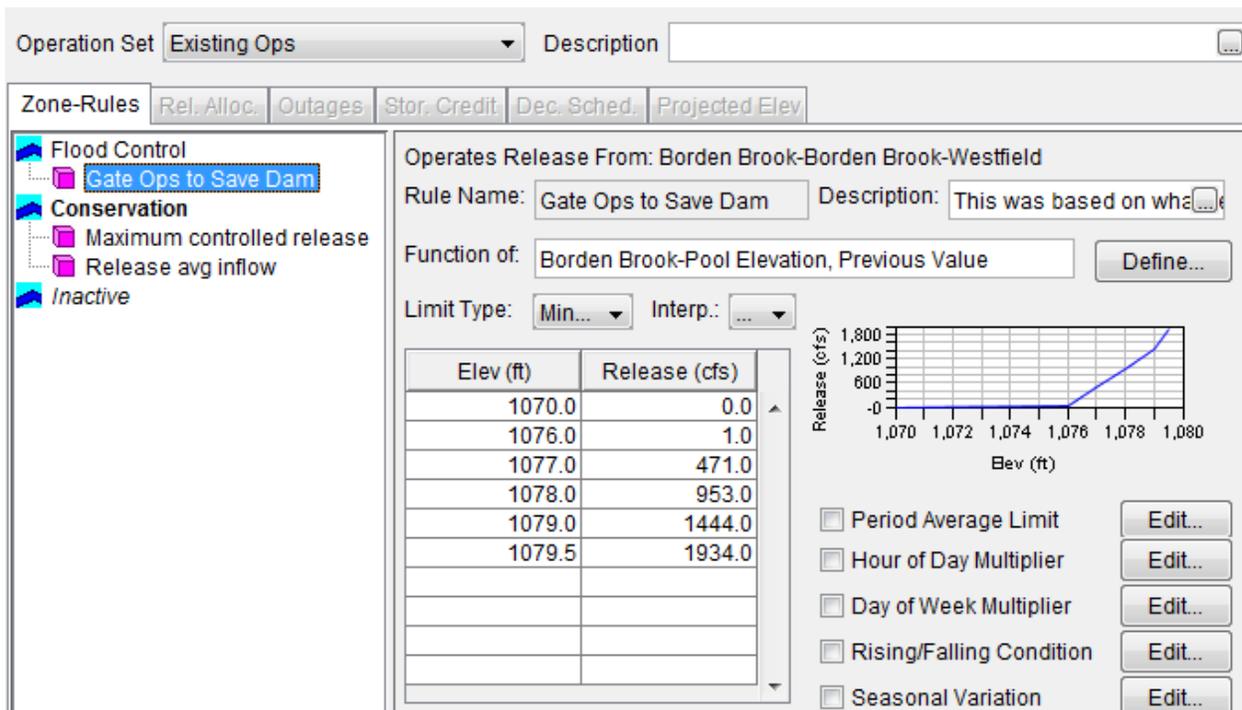


Figure 7: Reservoir Editor -- Operations Tab – Existing Ops OpSet – Gates Ops to save Dam

### 2. Maximum controlled release

Figure 8 shows the content of “Maximum controlled release” rule. This rule represents the maximum release from reservoir as a function of date.

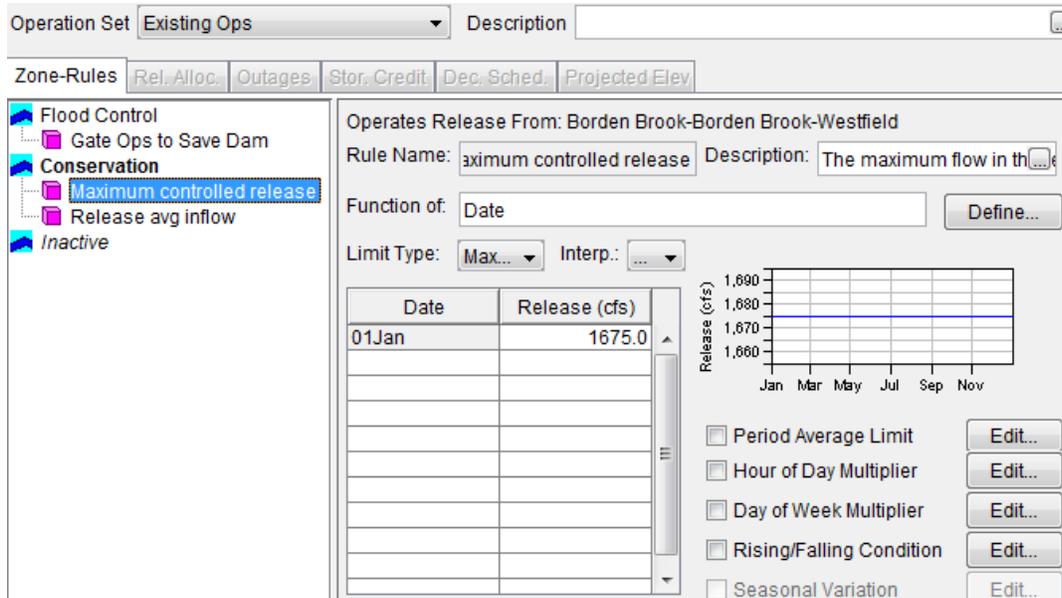


Figure 8: Reservoir Editor -- Operations Tab – Existing Ops OpSet – Maximum controlled release

### 3. Release avg Inflow

Figure 9 shows the content of “Release avg Inflow” rule. This rule represents the maximum release from reservoir as a function of Inflow.

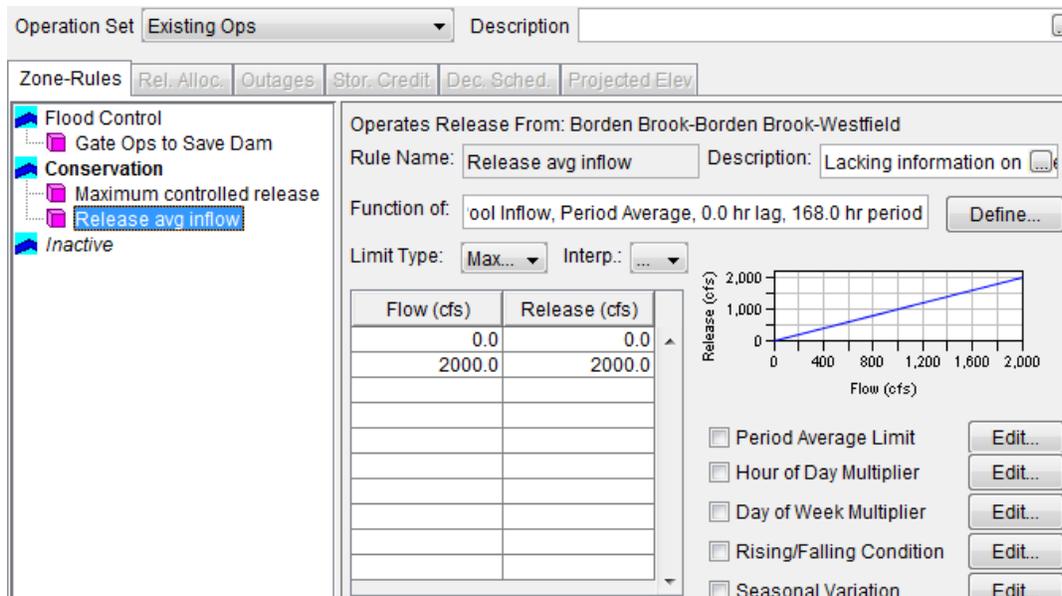


Figure 9: Reservoir Editor -- Operations Tab – Existing Ops OpSet – Release avg inflow

# Canaan

## I. Overview

The Canaan Hydroelectric Project is an existing licensed minor hydroelectric project owned and operated by Public Service of New Hampshire (PSNH). It is located at river mile 370 on the Connecticut River, ten miles below Murphy Dam and 80 miles upstream of Gilman Dam. The project is located in the towns of Canaan, Vermont and Stewartstown, New Hampshire. It was originally constructed by the W.F. Allen Company in 1927; the dam, a concrete gravity structure, was reconstructed in 1943 to replace the timber dam that failed. The purpose of the dam is to impound water for hydroelectric power generation, however, it is currently operated on a strict run-of-river basis.

Figure 1 shows the location of Canon as it is represented in the HEC-ResSim model. Figure 2 shows a photo of the project.

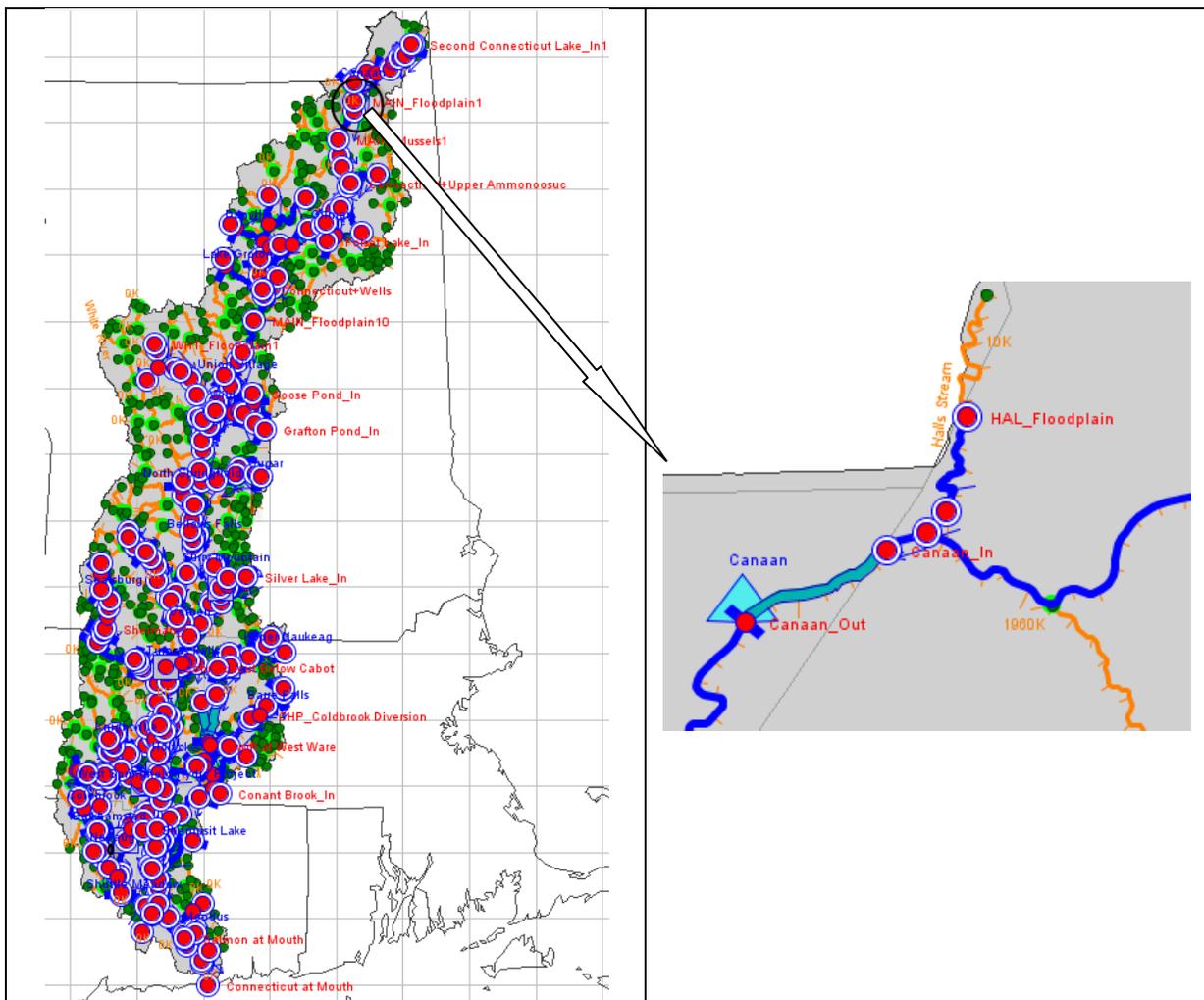


Figure 1: HEC-ResSim Map Display Showing Location of Caanan



**Figure 2: Photo of Canaan Hydroelectric project**

## **II. Physical Characteristics**

The physical characteristics of the reservoir are separated between the Pool and the Dam in the HEC-ResSim model. The elevation-storage-area defines the pool as shown in Figure 3<sup>13</sup>. The dam consists of seven types of outlets: (1) uncontrolled Bay#1, (2) uncontrolled Bay#5 (flashboards all in), (3) uncontrolled Bay#5 (flashboards partly cleared), (4) uncontrolled Bay#2, (5) uncontrolled Bay#3, (6) uncontrolled Bay#4 , and (7) controlled Tunnel discharge as shown in Figure 4<sup>14</sup>. The power plant has a maximum capacity of 550 cfs and a constant tailwater elevation of 1031.5 feet.

<sup>13</sup> NHDam Data Sheet. Canaan. 2003.

<sup>14</sup> National Dam Inspection Program. Phase I Inspection Report Canaan. 1980.





## B. Rule Illustrations

Figure 6 shows a set of operational rules specified for each zone that reflects the operation set named Existing Ops<sup>15</sup>.

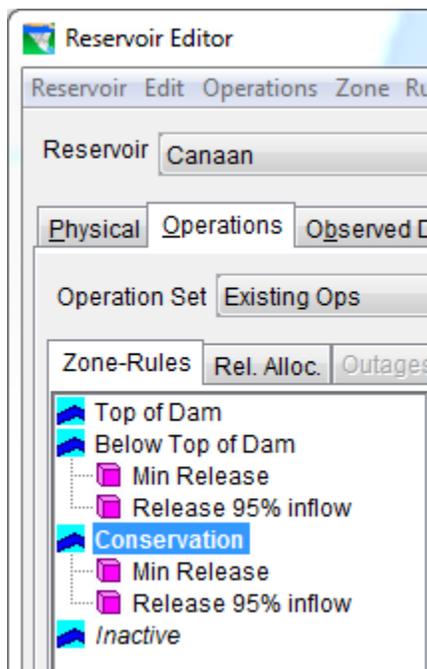


Figure 6: Reservoir Editor -- Operations Tab -- Existing Ops OpSet -- Zones and Rules

<sup>15</sup> Public Service of New Hampshire. Canaan Hydroelectric Project: Flow Management and Impoundment & Flow Monitoring Plan. 2010.

## C. Rule Descriptions

### 1. Min Release

Figure 7 shows the content of “Min Release” rule. This rule represents the constant minimum release from the dam.

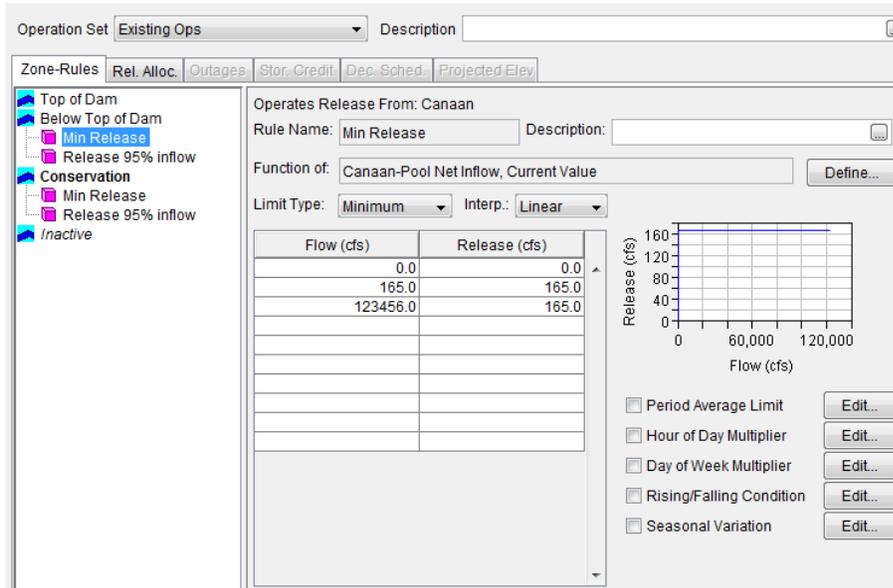


Figure 7: Reservoir Editor -- Operations Tab – Existing Ops OpSet – Min Release

### 2. Release 95% Inflow

Figure 8 shows the content of “Release 95% Inflow” rule. This rule passes 95% of Inflow through power plant as per the run-of-river modeling strategy.

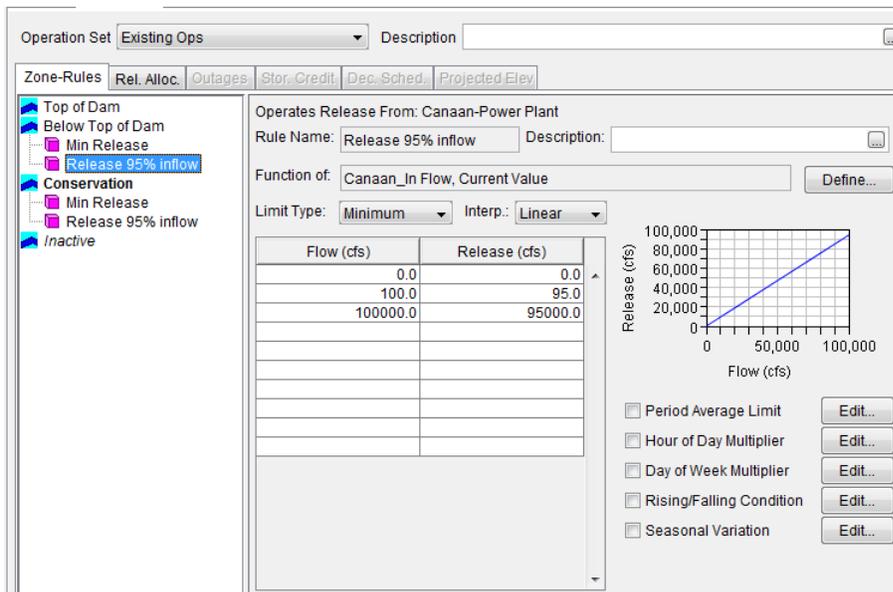


Figure 8: Reservoir Editor -- Operations Tab – Existing Ops OpSet – Release 95% Infl

# Cobble Mountain

## I. Overview

Cobble Mountain dam is located in Granville, MA and feeds into the Westfield River. It is owned by the City of Springfield and is used for drinking water supply for the city.

Figure 1 shows the location of Cobble Mountain Dam as it is represented in the HEC-ResSim model. Figure 2 shows a photo of Cobble Mountain reservoir.

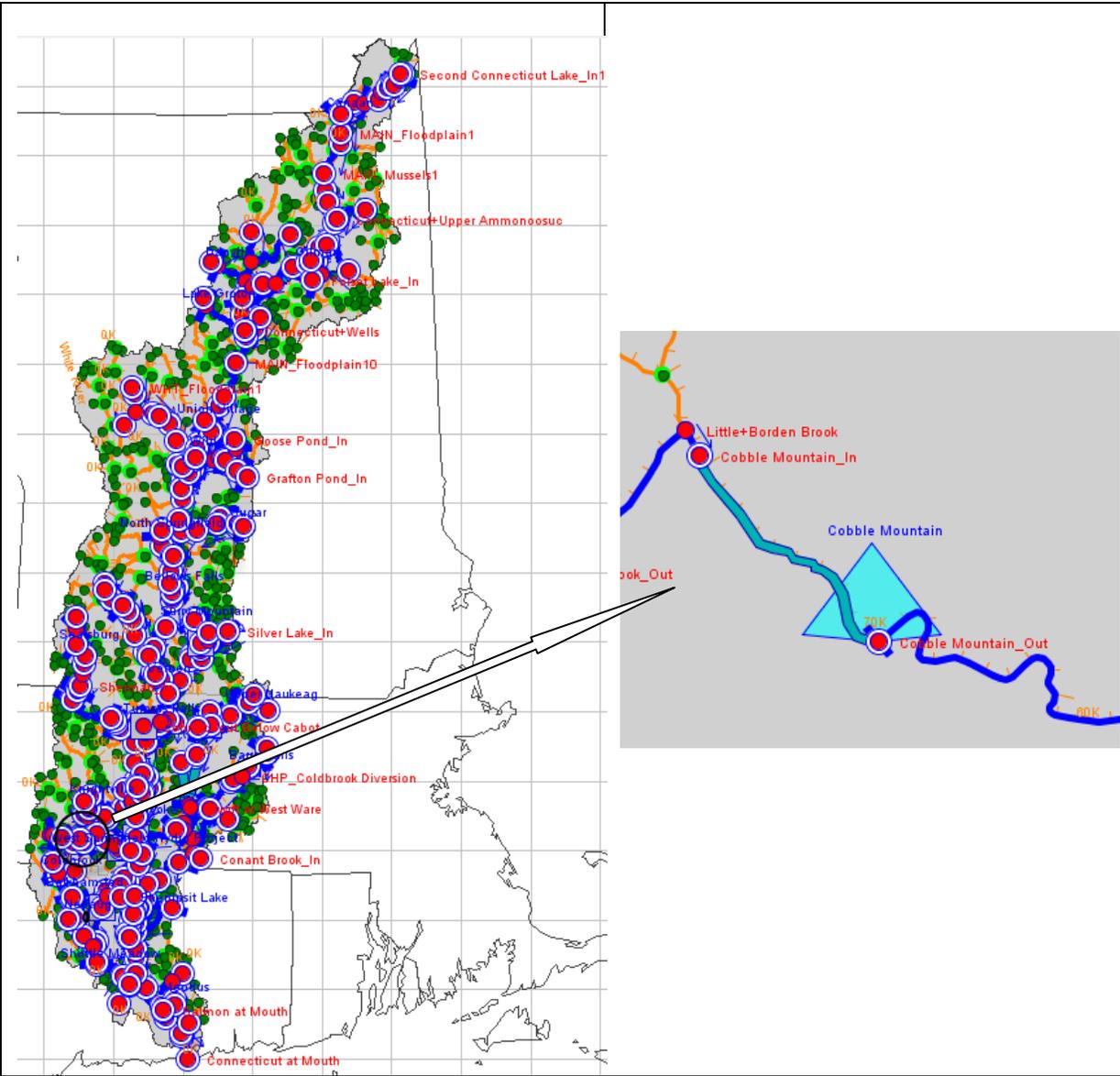


Figure 1: HEC-ResSim Map Display Showing Location of Cobble Mountain dam



**Figure 2: Photo of Cobble Mountain reservoir**

## **II. Physical Characteristics**

The physical characteristics of the reservoir are separated between the Pool and the Dam in the HEC-ResSim model. The elevation-storage-area defines the pool as shown in Figure 3<sup>16</sup>. The dam consists of two types of outlets: (1) controlled slide gates, and (2) uncontrolled outlet, as shown in Figure 4.

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<sup>16</sup> Springfield Water and Sewer Commission. Water Supply System History and Statistics. 1999

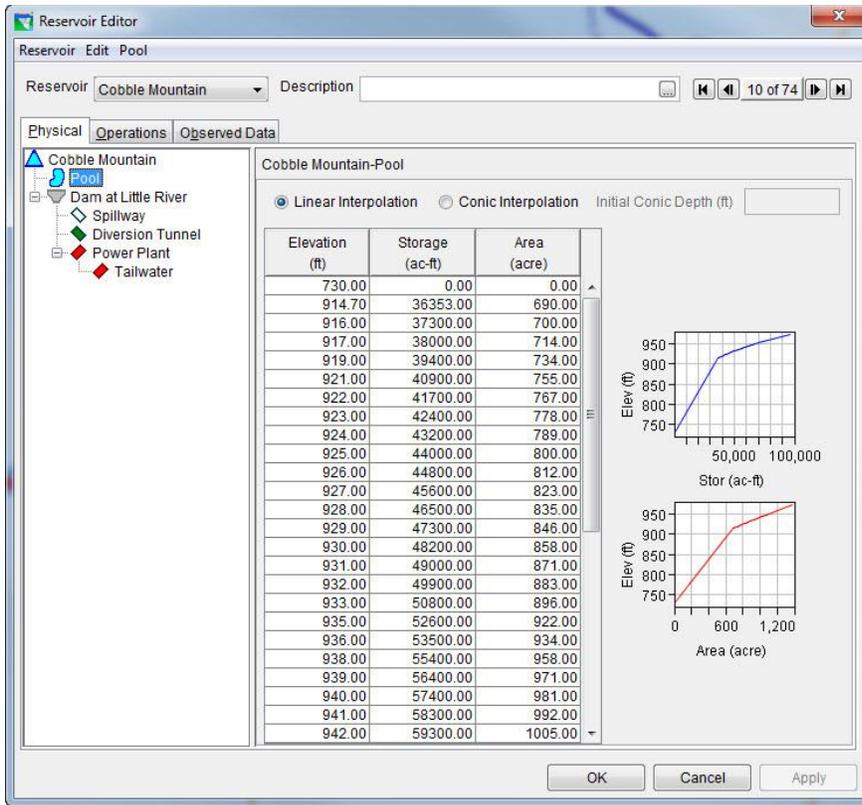


Figure 3: Reservoir Editor: Physical Tab -- Pool

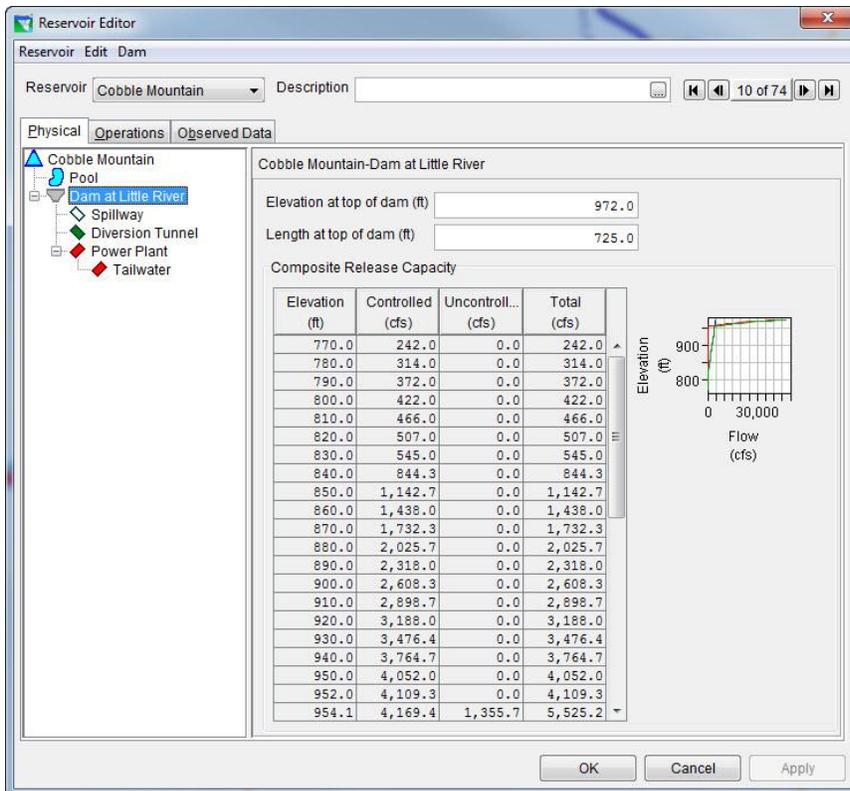


Figure 4: Reservoir Editor: Physical Tab -- Dam





# Colebrook

## I. Overview

Completed in 1969, Colebrook River Dam is owned and operated by the Metropolitan District Commission (MDC), a non-profit municipal corporation chartered to supply drinking water and sewage treatment to Hartford and its surrounding municipalities. During flood conditions, the Corps is responsible for water releases. The primary function of the reservoir is for flood control. The water storage capacity of Colebrook is approximately 10 BG, while the total capacity of the dam is approximately 31.5 BG. Colebrook is FERC licensed to the MDC and authorized for 3,000 KW<sup>17</sup>.

Figure 1 shows the location of Colebrook Dam as it is represented in the HEC-ResSim model, and Figure 2 shows a photo from Colebrook Dam.

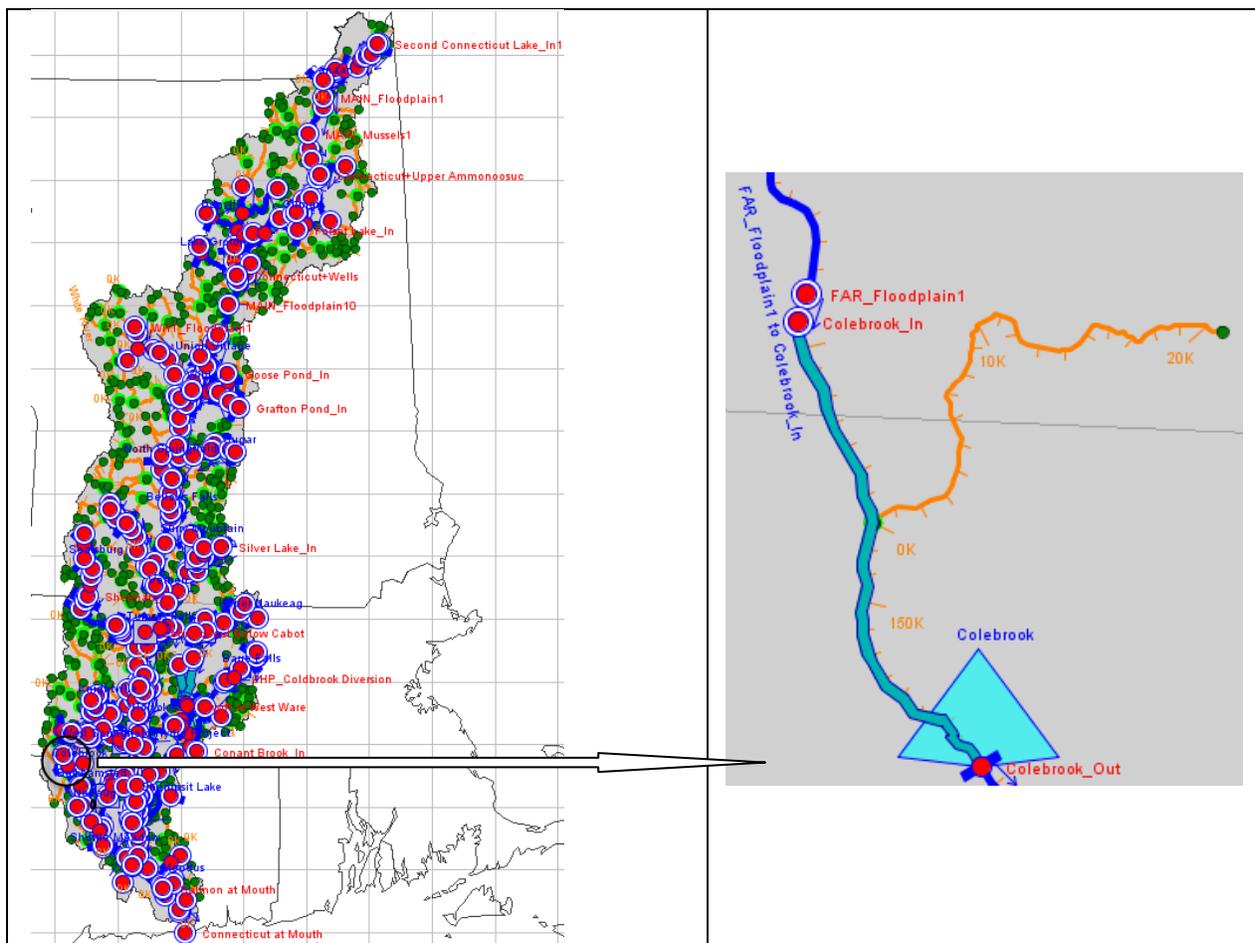


Figure 1 HEC-ResSim Map Display Showing Location of Colebrook dam

<sup>17</sup> Adamec, K. *Farmington Model Documentation*. University of Massachusetts, 2009.



**Figure 2: Photo of Colebrook dam**

## **II. Physical Characteristics**

The physical characteristics of the reservoir are separated between the Pool and the Dam in the HEC-ResSim model. The elevation-storage-area defines the pool as shown in Figure 3. The dam consists of three types of outlets: (1) controlled outlet, and (2) uncontrolled outlet, and (3) power plant as shown in Figure 4. All physical and operations data and are from Adamec 2009 and the US Army Corps New England District, either from a previously created ResSim model or the Reservoir Regulation Team website<sup>18</sup>.

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<sup>18</sup> [http://rsgisias.crrel.usace.army.mil/nae/cwms\\_map.map\\_index](http://rsgisias.crrel.usace.army.mil/nae/cwms_map.map_index)

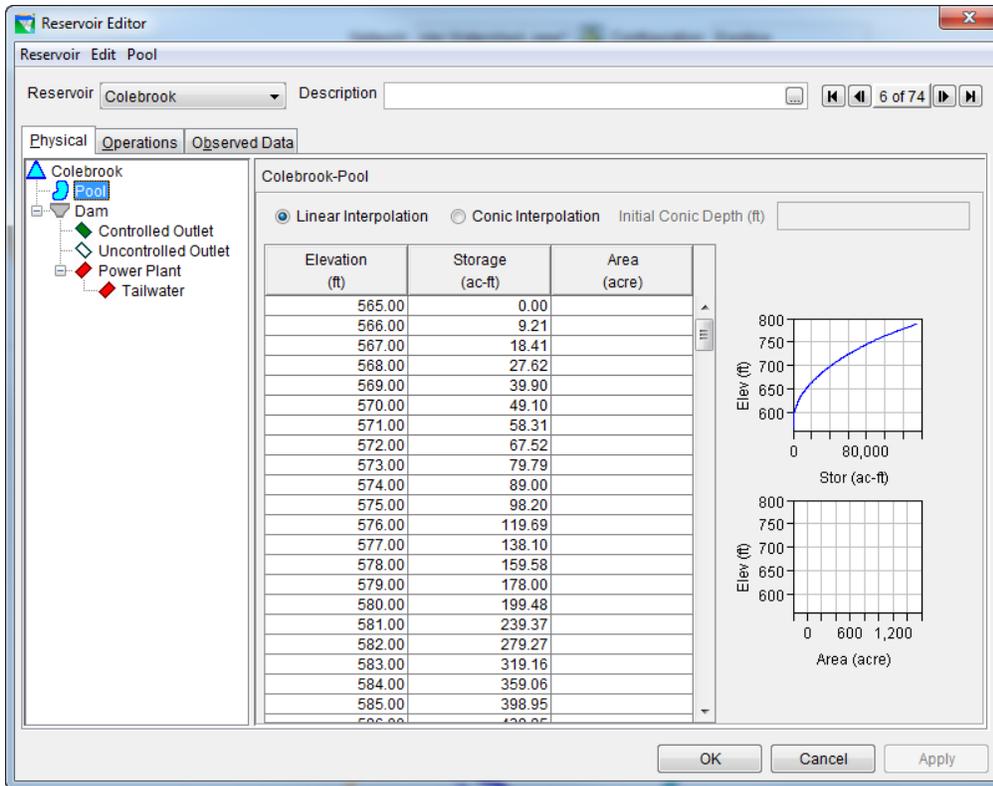


Figure 3: Reservoir Editor: Physical Tab -- Pool

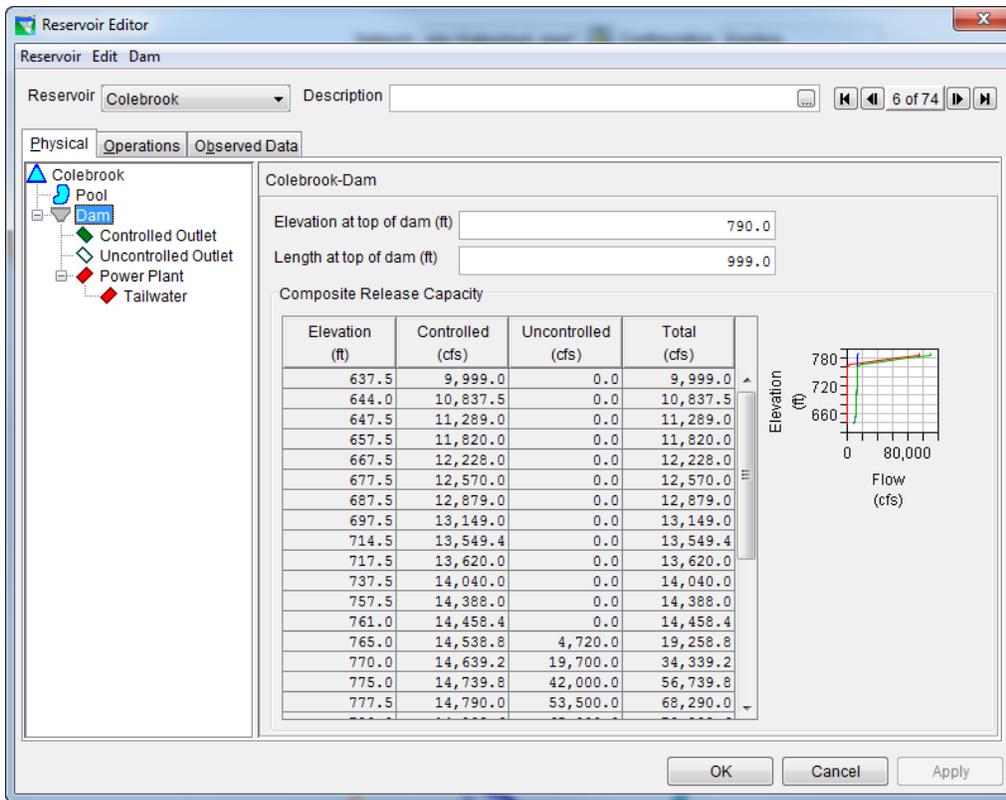


Figure 4: Reservoir Editor: Physical Tab -- Dam

### III. Operations

#### A. Operation Set

Zones are used to define the operational storage in the reservoir to determine the reservoir release through analysis of the rules contained within each zone. Figure 5 shows the definition of Colebrook’s “Existing Ops” operational zones, which consist of zones of Top of dam (790 ft), Flood Control (761 ft), Spring & Fall Fisheries Storage (708-714.5 ft), MDC Water Supply (701.2 ft), Operational Inactive (644 ft), and Inactive zone (640 ft).

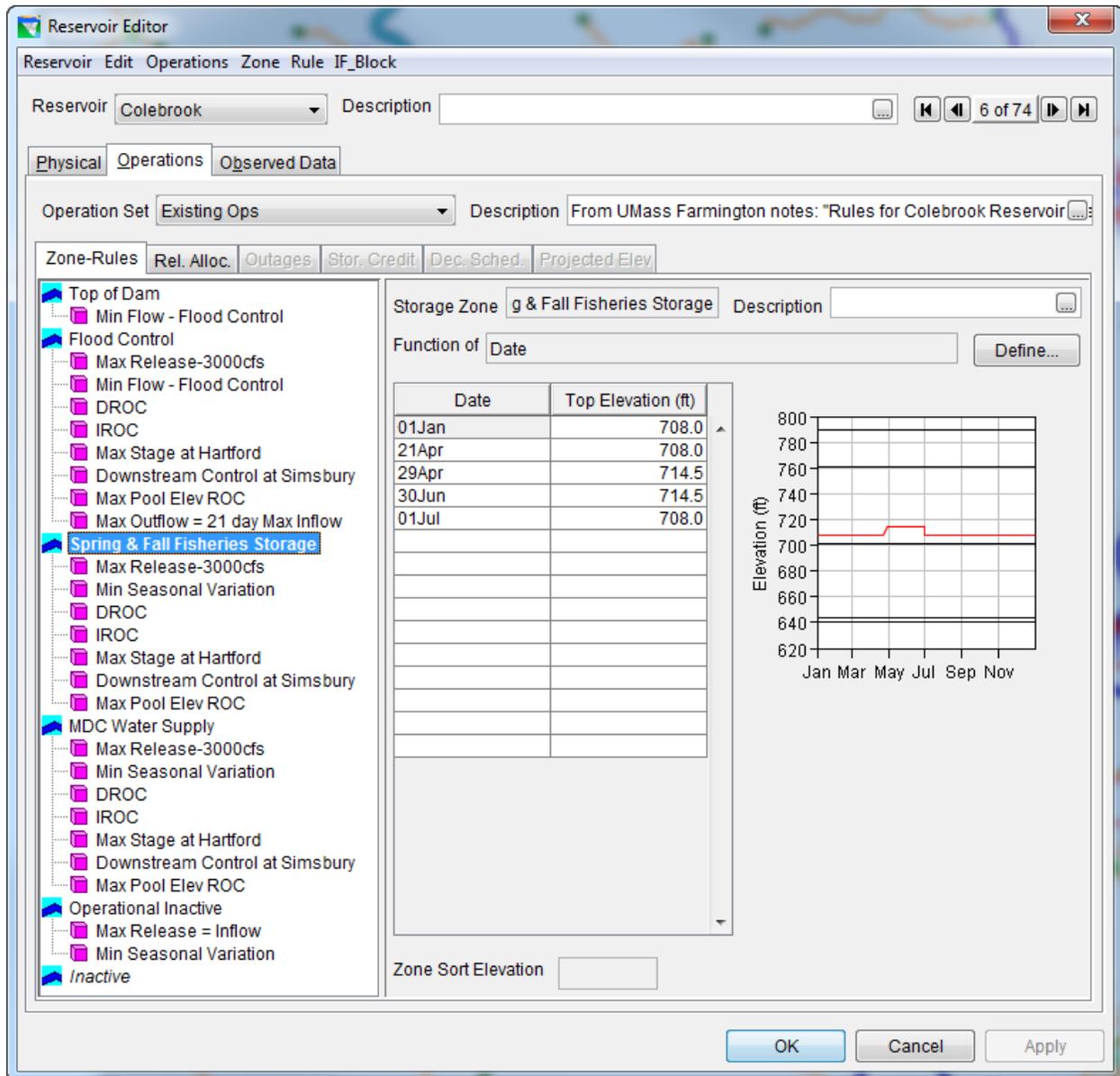


Figure 5: Reservoir Editor: Operations Tab –Existing Ops OpSet – Guide Curve

## B. Rule Illustrations

Figure 6 shows a set of operational rules specified for each zone that reflects the operation set named Existing Ops<sup>19</sup>. As described in the Simulation/Verification section of the report, adjustments were made to the operations to closer match gauge data.

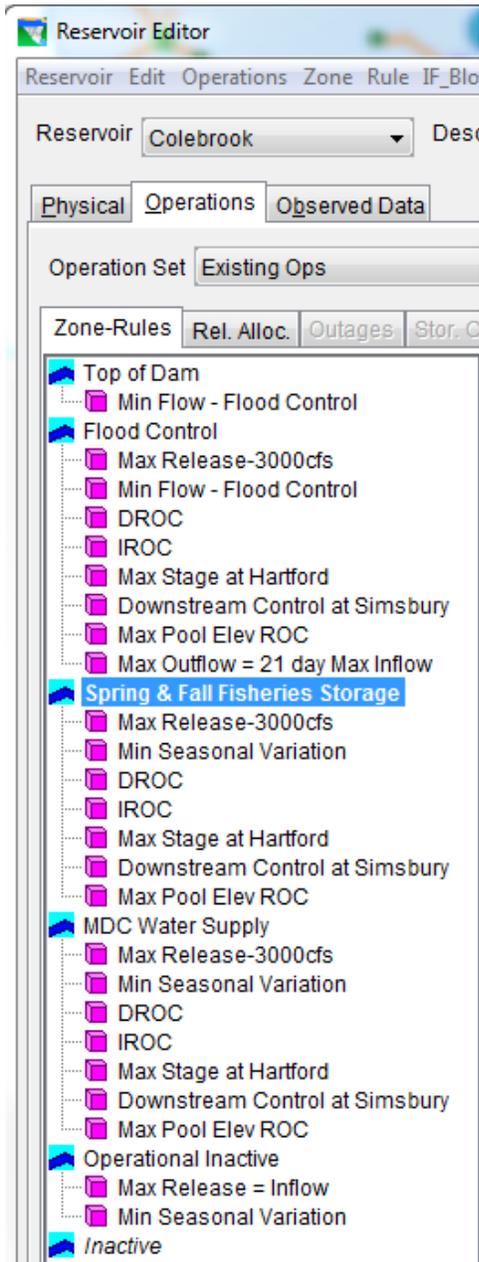
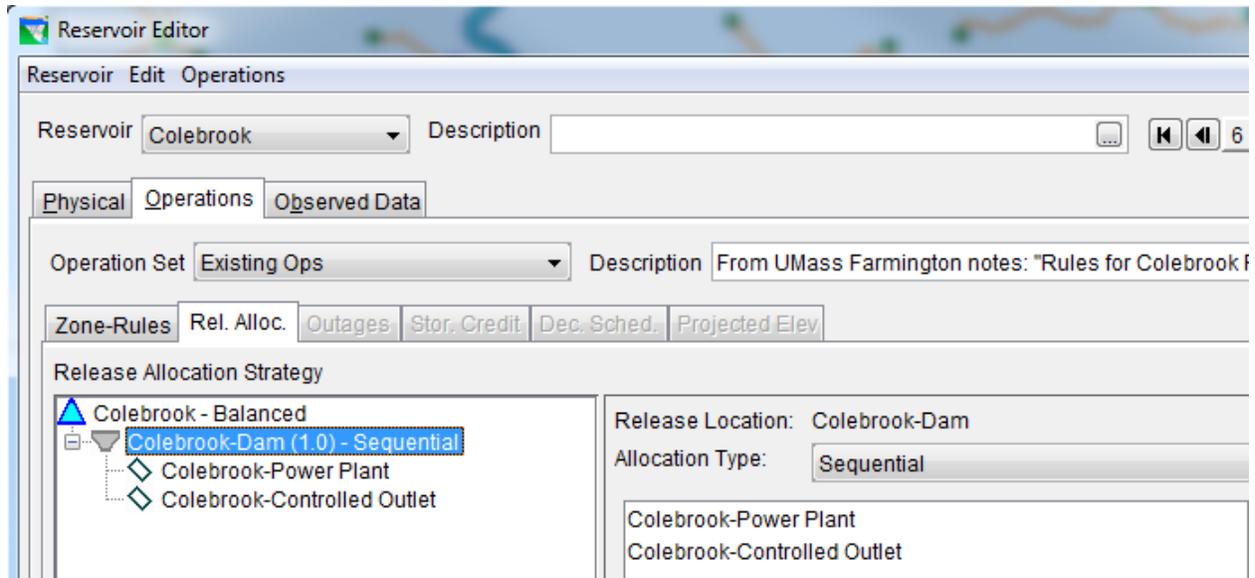


Figure 6: Reservoir Editor: Operations Tab – Existing OpSet – Zones and Rules

<sup>19</sup> Adamec 2009

Figure 7 shows a sequential release allocation approach specified for available outlets along Colebrook Dam. The available outlets are given an order of priority for release. The power plant gets the release first until it reaches release capacity. The controlled gate gets the remainder of the release.



**Figure 7: Reservoir Editor: Operations Tab – Existing Ops OpSet – Release Allocation**





#### 4. Increasing-ROC

Figure 11 shows the content of “Increasing-ROC” rule. This rule shows the maximum allowable increasing release rate of change as a function of release from Colebrook dam.

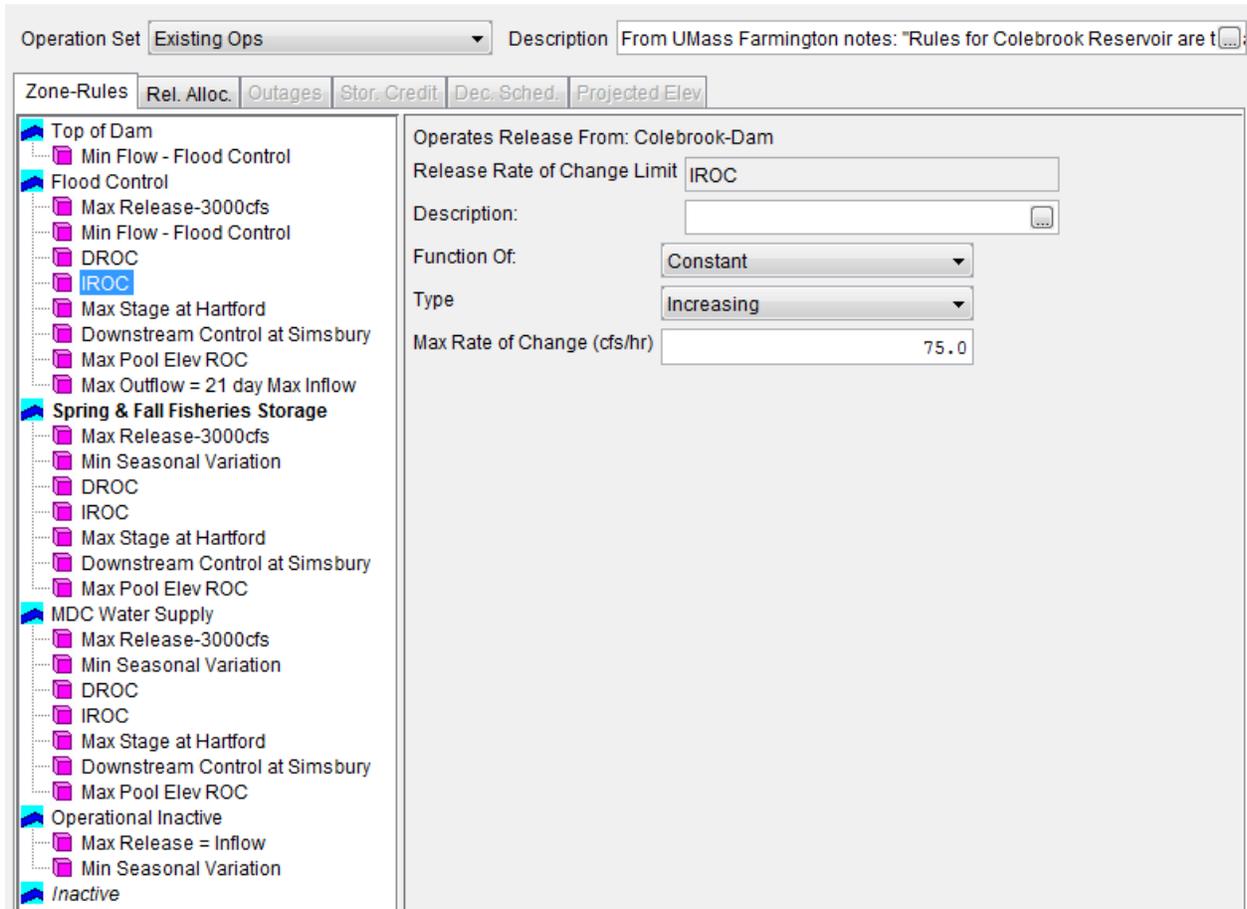


Figure 11: Reservoir Editor: Operations Tab – Existing Ops OpSet – Increasing-ROC

### 5. Max Stage at Hartford

Figure 12 shows the content of “Max Stage at Hartford” rule. This rule represents the maximum allowable release from dam as a function of previous day stage at Hartford. The previous day stage was used to account for the delay that occurs between the stage exceeding the specified target and the change in operations at the flood control dams that occurs in reality.

Operation Set: Existing Ops    Description: From UMass Farmington notes: "Rules for Colebrook Reservoir are t...

Zone-RULES: Rel. Alloc. | Outages | Stor. Credit | Dec. Sched. | Projected Elev.

- Top of Dam
  - Min Flow - Flood Control
- Flood Control
  - Max Release-3000cfs
  - Min Flow - Flood Control
  - DROC
  - IROC
  - Max Stage at Hartford**
  - Downstream Control at Simsbury
  - Max Pool Elev ROC
  - Max Outflow = 21 day Max Inflow
- Spring & Fall Fisheries Storage
  - Max Release-3000cfs
  - Min Seasonal Variation
  - DROC
  - IROC
  - Max Stage at Hartford
  - Downstream Control at Simsbury
  - Max Pool Elev ROC
- MDC Water Supply
  - Max Release-3000cfs
  - Min Seasonal Variation
  - DROC
  - IROC
  - Max Stage at Hartford
  - Downstream Control at Simsbury
  - Max Pool Elev ROC
- Operational Inactive
  - Max Release = Inflow
  - Min Seasonal Variation
- Inactive

Operates Release From: Colebrook-Dam

Rule Name: Max Stage at Hartford    Description:

Function of: Connecticut at Hartford Stage, Previous Value    Define...

Limit Type: Maximum    Interp.: Linear

Stage (ft)	Release (cfs)
0.0	3000.0
18.0	3000.0
19.0	2400.0
20.0	1800.0
21.0	1200.0
22.0	600.0
23.0	50.0
50.0	50.0

Period Average Limit    Edit...  
 Hour of Day Multiplier    Edit...  
 Day of Week Multiplier    Edit...  
 Rising/Falling Condition    Edit...  
 Seasonal Variation    Edit...

Figure 12: Reservoir Editor: Operations Tab – Existing Ops OpSet – Max stage at Hartford

### 6. Downstream Control at Simsbury

Figure 13 shows the content of “Downstream Control at Simsbury” rule. This rule shows the maximum allowable flow at the Farmington at Simsbury point downstream.

The screenshot displays the 'Operations Tab' for the 'Downstream Control at Simsbury' rule. The 'Zone-Rules' tree on the left shows the rule is selected. The main configuration area includes the following details:

- Operates Release From:** Colebrook
- Rule Name:** Downstream Control at Simsbury
- Function of:** Date
- Limit Type:** Maximum
- Interp.:** Step
- Downstream Location:** Farmington at Simsbury
- Parameter:** Flow

A table shows the flow limits for specific dates:

Date	Flow (cfs)
01Jan	9250.0
01May	5600.0
01Nov	9250.0

To the right of the table is a line graph showing 'Flow (cfs)' on the y-axis (ranging from 6,000 to 9,000) and months on the x-axis (Jan, May, Sep). The graph shows a step function where the flow is 9,250 cfs from Jan to May, drops to 5,600 cfs in May, and returns to 9,250 cfs from Sep onwards.

Additional options on the right include checkboxes for 'Period Average Limit', 'Hour of Day Multiplier', 'Day of Week Multiplier', 'Seasonal Variation', and 'Flow Contingency', each with an 'Edit...' button. An 'Advanced Options' button is located at the bottom right.

Figure 13: Reservoir Editor: Operations Tab – Existing Ops OpSet – Downstream Control at simsbury

### 7. Max Pool Elev ROC

Figure 14 shows the content of “Max pool Elev ROC” rule. This rule shows the maximum allowable decreasing rate of pool elevation change.

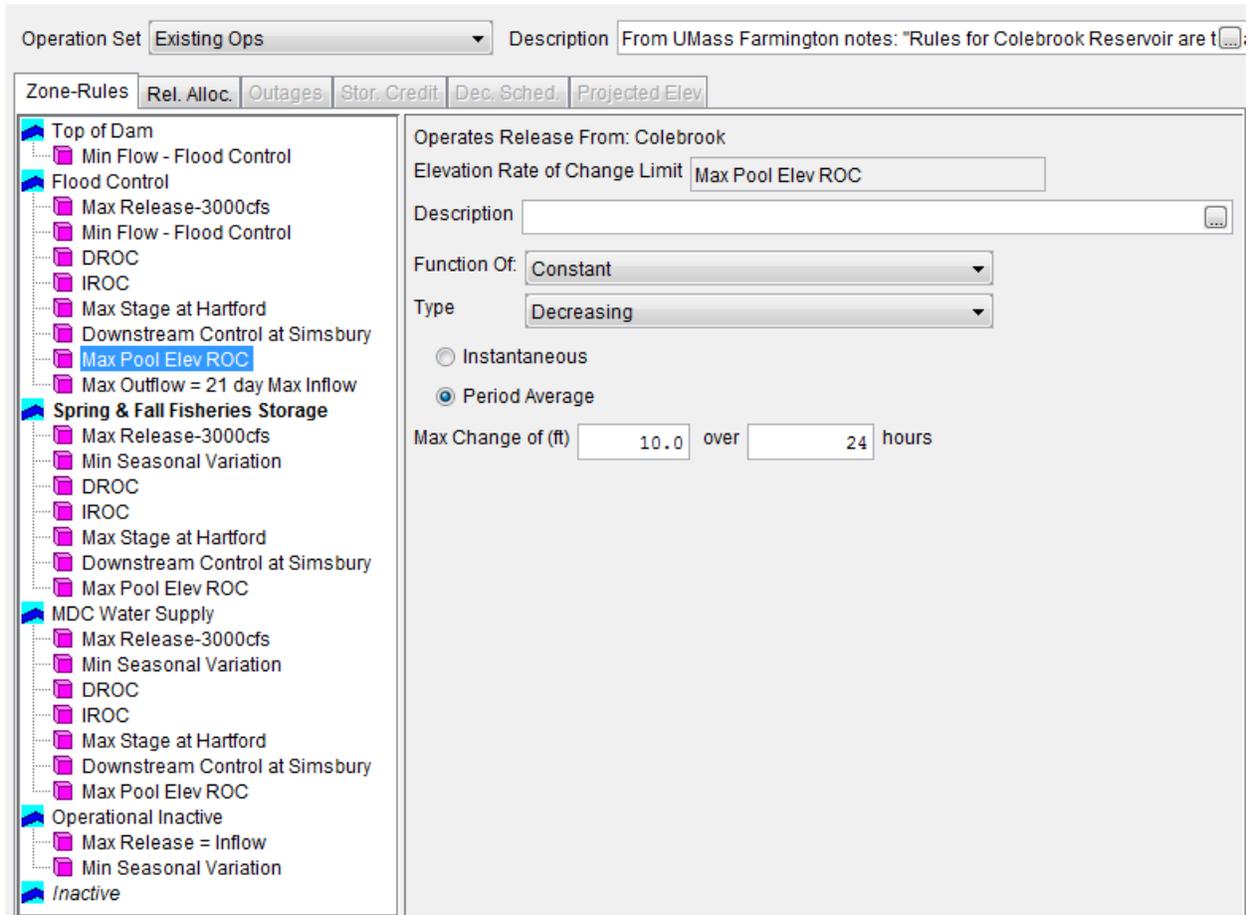


Figure 14: Reservoir Editor: Operations Tab – Existing Ops OpSet – Max Pool Elev ROC

**8. Max Outflow equals 21 day Max Inflow**

Figure 15 shows the content of “Max Outflow equals 21 day Max Inflow” rule. This rule represents the maximum release from dam as a function of the previous 3 weeks of inflow.

The screenshot shows the 'Reservoir Editor' software interface. At the top, the 'Operation Set' is 'Existing Ops' and the 'Description' is 'From UMass Farmington notes: "Rules for Colebrook Reservoir are t...'. The 'Zone-Rules' tab is active, showing a tree view on the left with the rule 'Max Outflow = 21 day Max Inflow' selected. The main configuration panel for this rule is displayed, showing the following details:

- Operates Release From:** Colebrook
- Rule Name:** outflow = 21 day Max Inflow
- Description:** (empty)
- Function of:** Colebrook-Pool Inflow, Period Maximum, 0.0 hr lag, 504.0 hr period
- Limit Type:** Maximum
- Interp.:** Linear

A table shows the relationship between Flow (cfs) and Release (cfs):

Flow (cfs)	Release (cfs)
0.0	0.0
123456.0	123456.0

To the right of the table is a graph with 'Flow (cfs)' on the x-axis (0 to 120,000) and 'Release (cfs)' on the y-axis (0 to 140,000). A blue line represents the linear relationship between flow and release, starting at (0,0) and ending at approximately (120,000, 120,000). Below the graph are several checkboxes for advanced settings, all of which are currently unchecked:

- Period Average Limit
- Hour of Day Multiplier
- Day of Week Multiplier
- Rising/Falling Condition
- Seasonal Variation

**Figure 15: Reservoir Editor: Operations Tab – Existing Ops OpSet – Max Outflow equals 21 day Max Inflow**

### 9. Min Seasonal Variation

Figure 16 shows the content of “Min Seasonal Variation” rule. This rule shows the minimum release from dam as a function of inflow for different months.

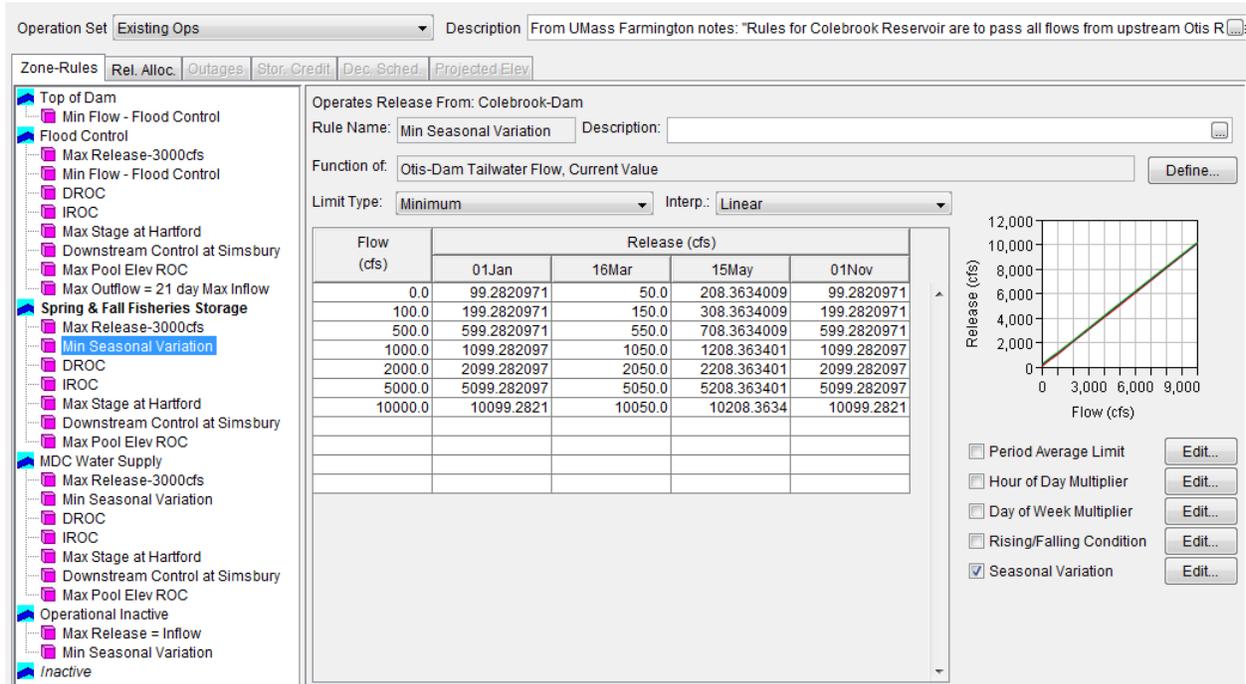


Figure 16: Reservoir Editor: Operations Tab – Existing Ops OpSet – Min Seasonal Variation

### 10. Max release=Inflow

Figure 17 shows the content of “Min Flow-Flood Control” rule. This rule releases total inflow from dam when the pool is in Operational Inactive zone.

Operation Set: Existing Ops Description: From UMass Farmington notes: "Rules for Colebrook Reservoir are to ..."

Zone-Rules: Rel. Alloc. Outages Stor. Credit Dec. Sched. Projected Elev.

- Top of Dam
  - Min Flow - Flood Control
- Flood Control
  - Max Release-3000cfs
  - Min Flow - Flood Control
  - DROC
  - IROC
  - Max Stage at Hartford
  - Downstream Control at Simsbury
  - Max Pool Elev ROC
  - Max Outflow = 21 day Max Inflow
- Spring & Fall Fisheries Storage
  - Max Release-3000cfs
  - Min Seasonal Variation
  - DROC
  - IROC
  - Max Stage at Hartford
  - Downstream Control at Simsbury
  - Max Pool Elev ROC
- MDC Water Supply
  - Max Release-3000cfs
  - Min Seasonal Variation
  - DROC
  - IROC
  - Max Stage at Hartford
  - Downstream Control at Simsbury
  - Max Pool Elev ROC
- Operational Inactive
  - Max Release = Inflow**
  - Min Seasonal Variation
- Inactive

Operates Release From: Colebrook

Rule Name: Max Release = Inflow Description:

Function of: Colebrook\_In Flow, Current Value Define...

Limit Type: Maximum Interp.: Linear

Flow (cfs)	Release (cfs)
0.0	0.0
999999.0	999999.0

Release (cfs)

Flow (cfs)

- Period Average Limit Edit...
- Hour of Day Multiplier Edit...
- Day of Week Multiplier Edit...
- Rising/Falling Condition Edit...
- Seasonal Variation Edit...

Figure 17: Reservoir Editor: Operations Tab – Existing Ops OpSet – Min Flow-Flood Control

## Comerford

### I. Overview

Comerford dam is located on the Connecticut River mainstem in the towns of Monroe, New Hampshire, and Barnet, Vermont. It is owned and operated by TransCanada Hydro Northeast Inc. as part of the 15 Mile Falls project for hydropower generation on a peaking, seasonal storage basis.

Figure 1 shows the location of Comerford dam as it is represented in the HEC-ResSim model. Figure 2 shows a photo of Comerford dam.

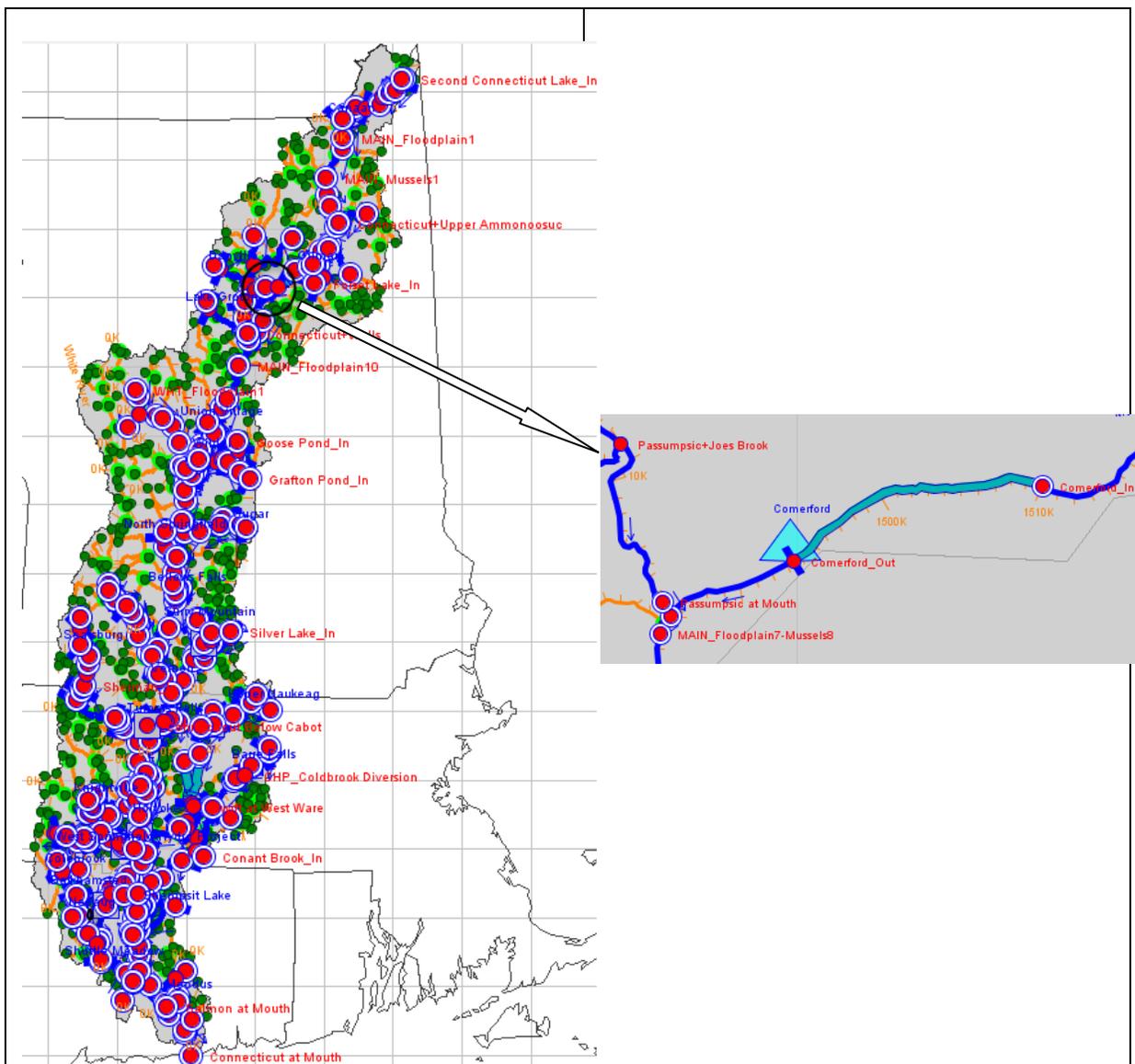


Figure 1: HEC-ResSim Map Display Showing Location of Comerford dam



Figure 2: Photo of Comerford dam.

## II. Physical Characteristics

The physical characteristics of the reservoir are separated between the Pool and the Dam in the HEC-ResSim model. The elevation-storage-area defines the pool as shown in Figure 3<sup>20</sup>. The dam consists of three types of outlets: (1) uncontrolled stanchion Bays, and (2) uncontrolled Flashboard Bays, and (3) power plant as shown in Figure 4.

---

<sup>20</sup> Data provided by TransCanada

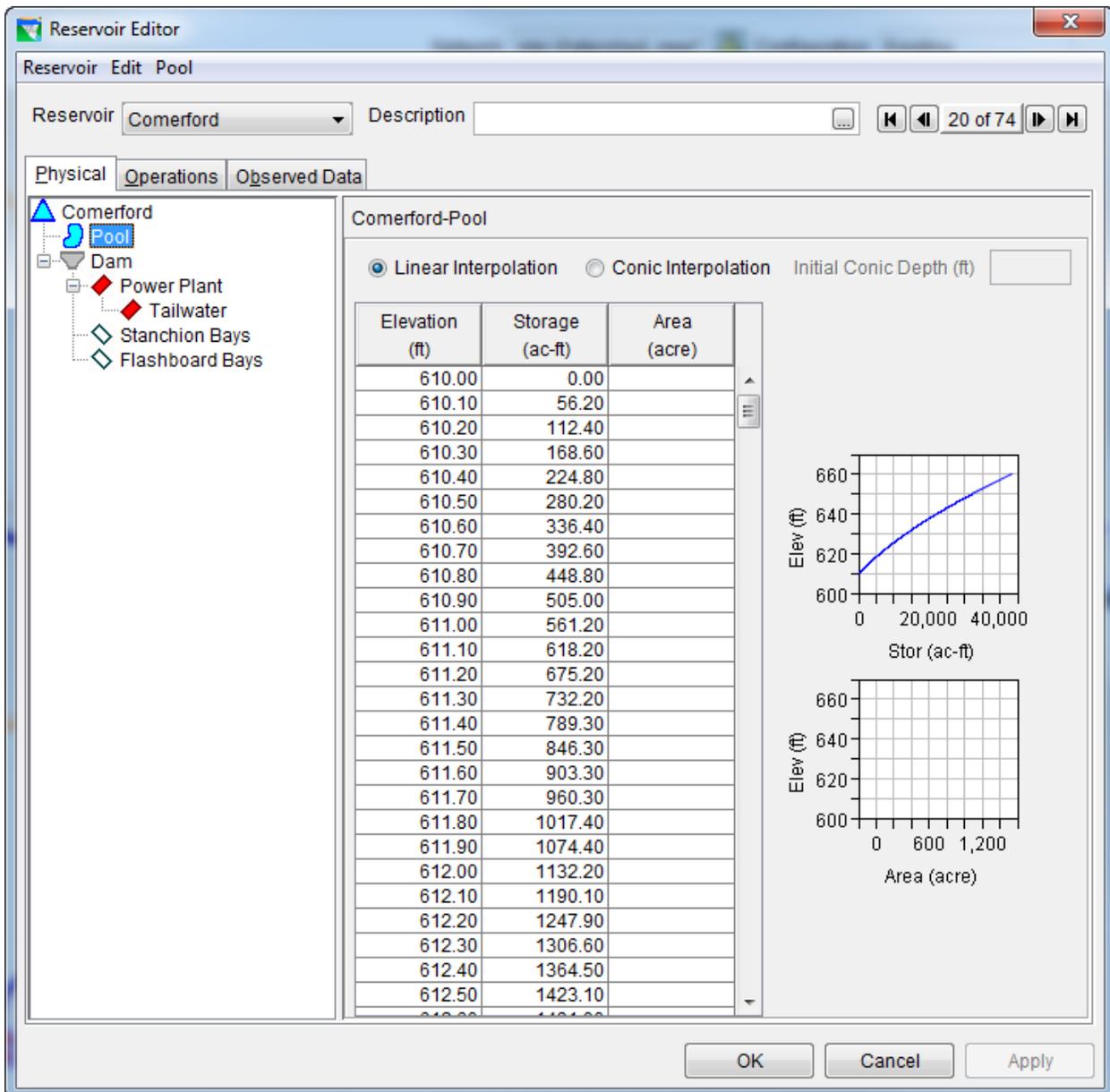


Figure 3: Reservoir Editor: Physical Tab -- Pool

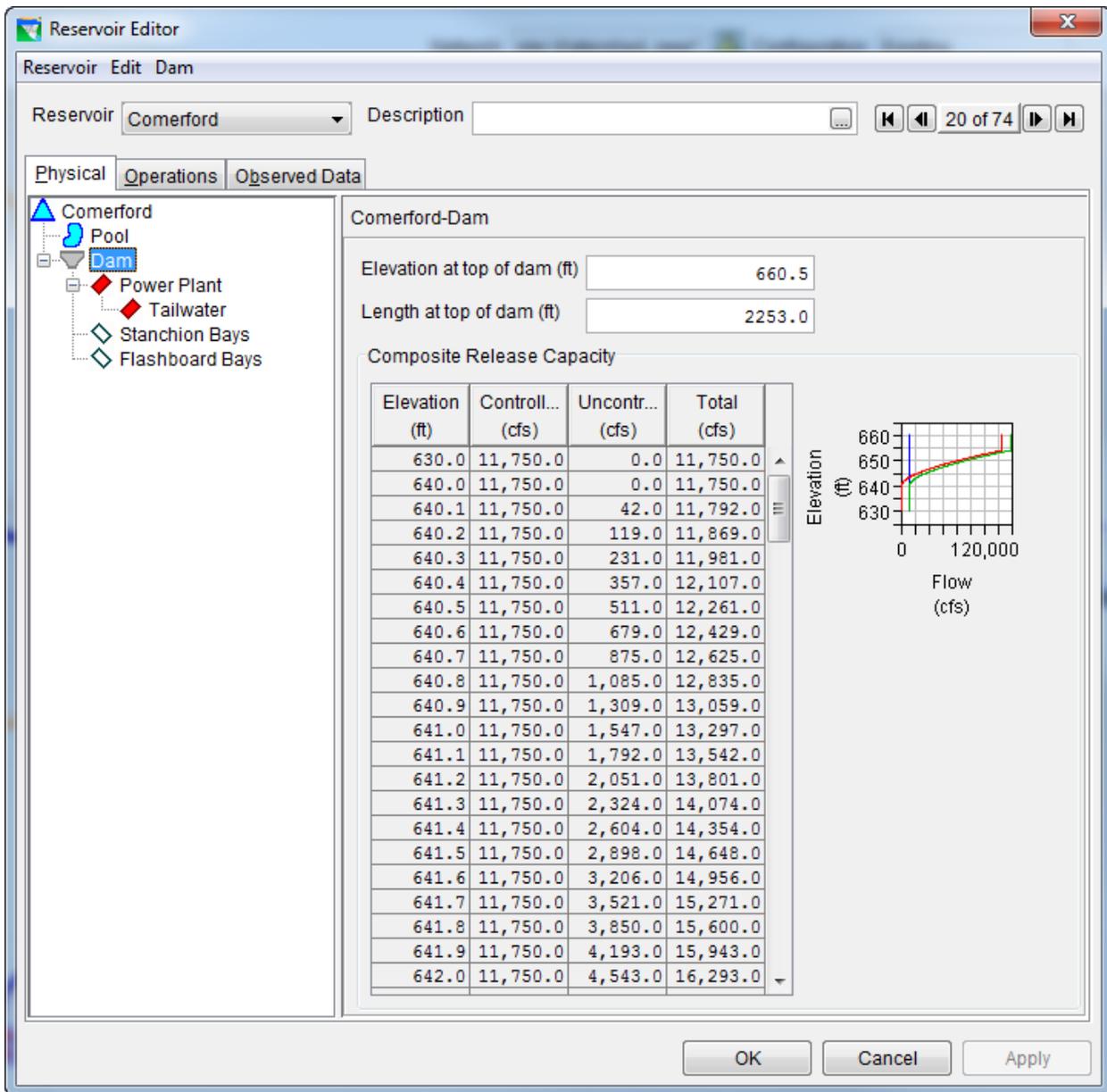


Figure 4: Reservoir Editor: Physical Tab -- Dam

### III. Operations

#### A. Operation Set

Zones are used to define the operational storage in the reservoir to determine the reservoir release through analysis of the rules contained within each zone. Figure 5 shows the definition of Comerford’s “Existing Ops” operational zones, which consist of zones of Top of dam (660.5 ft), Below Top of dam (650 ft), Conservation (635-648 ft), and Inactive zone (624 ft)<sup>1</sup>.

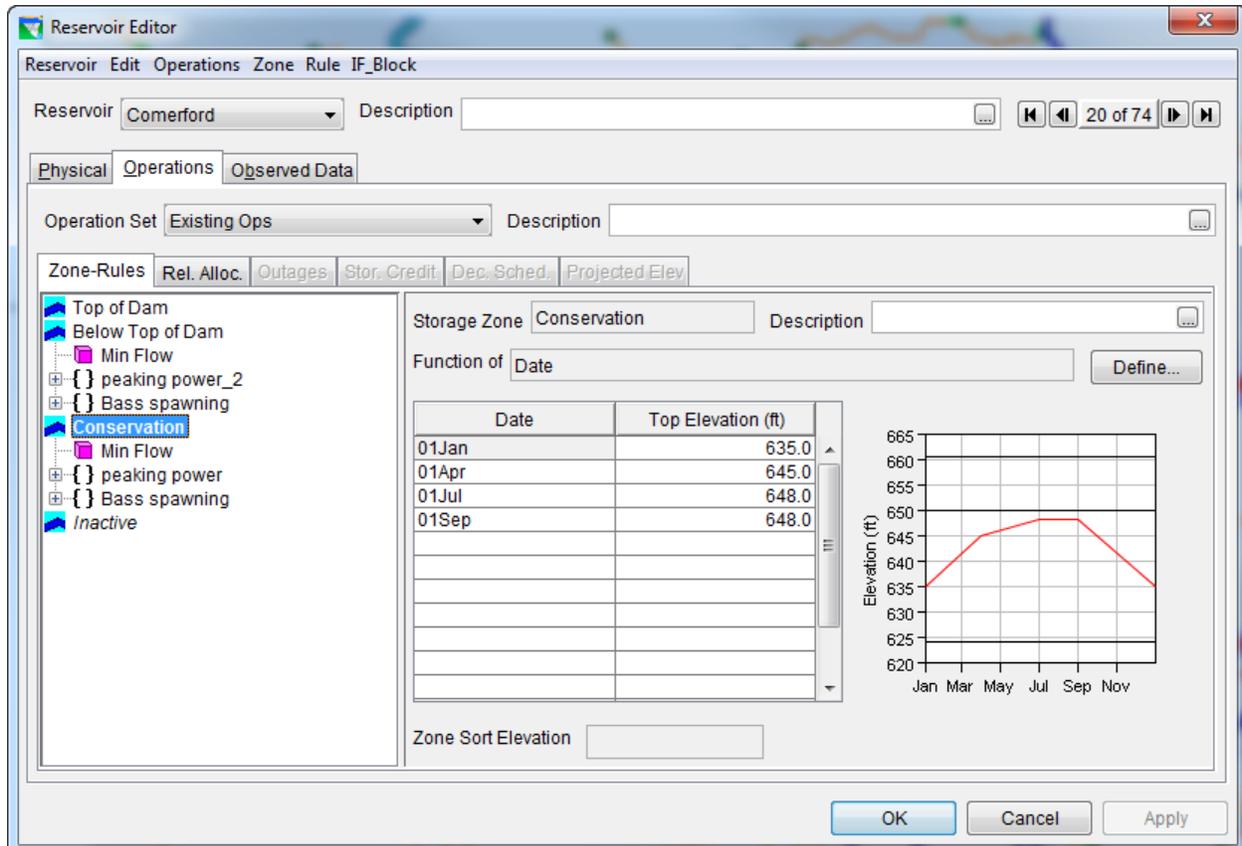


Figure 5: Reservoir Editor: Operations Tab –Existing Ops OpSet – Guide Curve

## B. Rule Illustrations

Figure 6 shows a set of operational rules specified for each zone that reflects the operation set named Existing Ops<sup>21</sup>.

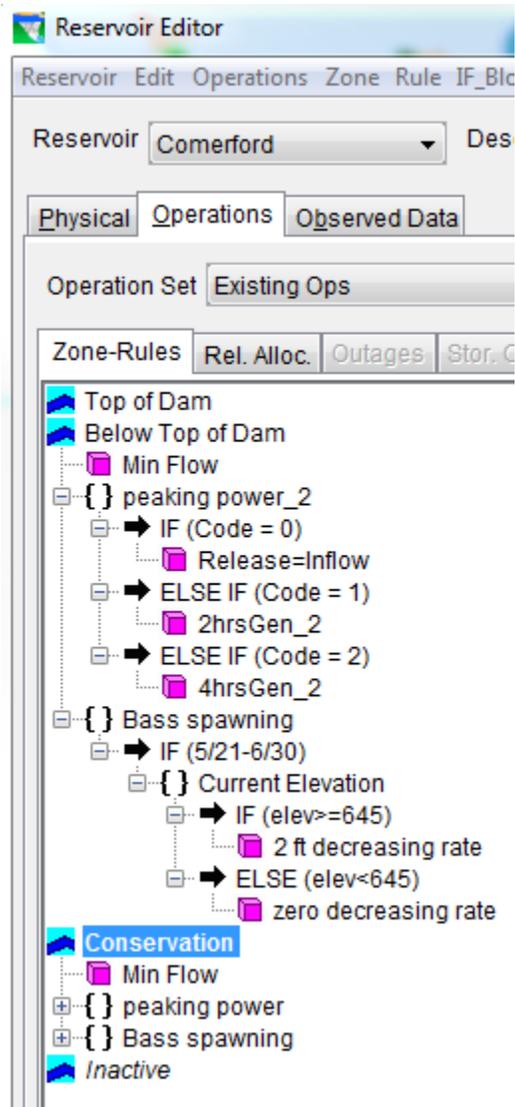


Figure 6: Reservoir Editor: Operations Tab – Existing Ops OpSet – Zones and Rules

<sup>21</sup> TransCanada. Connecticut River Operational Constraints. 2012.

## C. Rule Descriptions

### 1. Min Flow

Figure 7 shows the content of “Min Flow” rule. This rule shows the minimum release from dam.

The screenshot displays the 'Min Flow' rule configuration in the Reservoir Editor. The interface is divided into several sections:

- Left Panel (Tree View):** Shows a hierarchical structure of rules. The 'Min Flow' rule is highlighted under the 'Conservation' category. Other rules include 'peaking power\_2', 'Bass spawning', and 'Inactive'.
- Central Panel (Configuration):**
  - Operates Release From:** Comerford-Dam
  - Rule Name:** Min Flow
  - Function of:** Date
  - Limit Type:** Minimum
  - Interp.:** Step
  - Table:** A table with columns 'Date' and 'Release (cfs)'. The data points are:
 

Date	Release (cfs)
01Jan	1145.0
01Apr	1635.0
01Jun	818.0
01Oct	1145.0
- Right Panel (Graph and Options):**
  - Graph:** A line graph showing 'Release (cfs)' on the y-axis (ranging from 800 to 1,600) against months on the x-axis (Jan, Mar, May, Jul, Sep, Nov). The release rate is 1,145 cfs from Jan to Apr, jumps to 1,635 cfs in May, drops to 818 cfs in June, and returns to 1,145 cfs in October.
  - Options:** Several checkboxes are present, all of which are currently unchecked:
    - Period Average Limit
    - Hour of Day Multiplier
    - Day of Week Multiplier
    - Rising/Falling Condition
    - Seasonal Variation

Figure 7: Reservoir Editor: Operations Tab – Existing Ops OpSet – Min Flow

## 2. Peaking power\_2

Figure 8 shows the content of “peaking power\_2” rule. This rule represents the peaking power strategy applied for Comerford dam.

The screenshot displays the configuration of the "peaking power\_2" rule in a software interface. The interface is divided into several sections:

- Top Panel:** Shows the "Operation Set" as "Existing Ops" and a "Description" field.
- Zone-Rules Panel:** Contains tabs for "Rel. Alloc.", "Outages", "Stor. Credit", "Dec. Sched.", and "Projected Elev".
- Tree View (Left):** Shows a hierarchical structure of rules under "Top of Dam" and "Below Top of Dam". The "peaking power\_2" rule is highlighted.
- Main Configuration Panel (Right):**
  - Operates Release From: Comerford-Dam
  - Name: peaking power\_2
  - Description: [Empty]
  - Table of conditions:
 

Type	Name	Description
IF	Code = 0	
ELSE IF	Code = 1	
ELSE IF	Code = 2	
- Detailed Rule Configuration Panel (Bottom):**
  - Operates Release From: Comerford-Power Plant
  - Rule Name: Release=Inflow
  - Function of: Comerford-Pool Net Inflow, Current Value
  - Limit Type: Minimum, Interp.: Linear
  - Table of flow and release values:
 

Flow (cfs)	Release (cfs)
0.0	0.0
1000000.0	1000000.0
  - Graph showing Release (cfs) vs Flow (cfs) with a linear relationship.
  - Options for Period Average Limit, Hour of Day Multiplier, Day of Week Multiplier, Rising/Falling Condition, and Seasonal Variation.



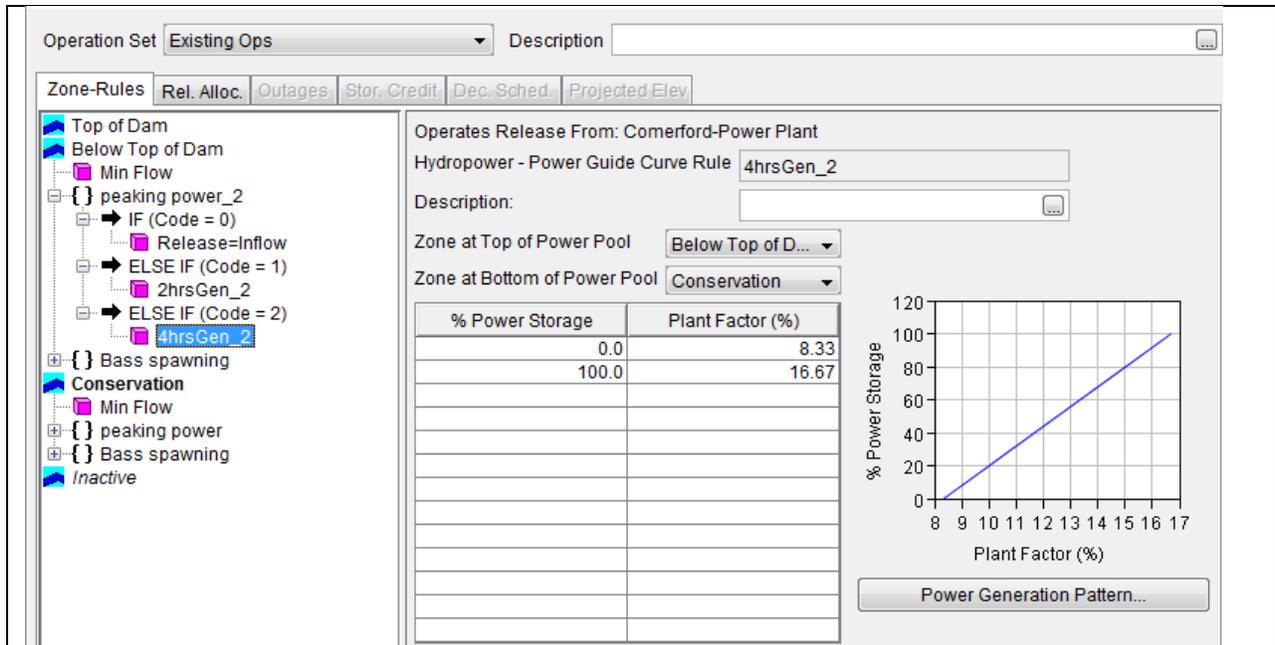


Figure 8: Reservoir Editor: Operations Tab – Existing Ops OpSet – peaking power\_2

Figure 9 describes the definition of codes used in the Comerford\_Volume state variable. The code is summing up the current Inflow and previous storage in each time step, compare it to the volume needed for generating 2 and 4 hours power and to the spillway storage minus inactive storage and then decide how much to release.

```

11 # Create a code to track the available water for generating power
12
13 #The code is summing up the current Inflow and previous storage in each timestep, compare it to the volume needed
14 #generating 2 and 4 hours power and to the spillway storage minus inactive storage and then decide how much to r
15
16 # Code =0: I+S >S (spillway storage)-S (inactive storage)
17 # code =1: 0< I+S<V(2hrs.Gen)
18 # code =2: V(2hrs.Gen)<I+S<V(4hrs.Gen)
19 # code =3: V(4hrs.Gen)<I+S
20
21 # S (spillway storage)-S (inactive storage)=390470-107790=282680(acf)
22 #outlet capacity=11750 (cfs)
23 #V(2hrs.Gen)=(2*outlet capacity)*0.082=1927(acf)
24 #V(4hrs.Gen)=(4*outlet capacity)*0.082=3854(acf)
25
26 from hec.model import RunTimeStep
27
28 Inflow_TS=network.getTimeSeries("Reservoir","Comerford", "Pool", "Flow-IN NET")
29 Inflow= Inflow_TS.getCurrentValue(currentRunTimestep)
30 Inflow_acf=Inflow*1.98
31
32 Storage_TS = network.getTimeSeries("Reservoir","Comerford", "Pool", "Stor")
33 Storage=Storage_TS.getPreviousValue(currentRunTimestep)
34
35 Volume=Inflow_acf+(Storage-109670)
36
37 if Volume > 282680:
38     Code=0
39 elif 0<Volume <=1927 :
40     Code=1
41 elif 1927<Volume <=3854:
42     Code=2
43 elif 3854<Volume<282680:
44     Code=3
45 else:
46     Code=4
47
48 currentVariable.setValue(currentRunTimestep,Code)

```

Figure 9: State Variable Editor: Comerford\_Volume

### 3. Bass spawning

Figure 10 shows the content of “Bass spawning” rule. This rule shows the different maximum elevation rate of change for elevations greater and less than 645 feet during 21May-30June.

The image displays two screenshots of a software interface for configuring rules. Both screenshots show the 'Operation Set' as 'Existing Ops' and the 'Description' field empty.

**Top Screenshot:** The 'Zone-Rules' tab is active. The left sidebar shows a tree view where 'Bass spawning' is expanded to 'IF (5/21-6/30)'. The main panel shows 'Operates Release From: Comerford-Power Plant' and 'IF Conditional: 5/21-6/30'. A table below shows conditions:

	Value1	Operator	Value2
	Current Time Step	>=	21May
AND	Current Time Step	<=	30Jun

Buttons for 'Add Cond.', 'Del. Cond.', 'Move Up', 'Move Down', and 'Evaluate' are visible.

**Bottom Screenshot:** The 'Zone-Rules' tab is active. The left sidebar shows 'Bass spawning' expanded to 'Current Elevation'. The main panel shows 'Operates Release From: Comerford-Power Plant' and 'Name: Current Elevation'. A table below shows the rule logic:

Type	Name	Description
IF	elev>=645	
ELSE	elev<645	

Operation Set: Existing Ops    Description:

Zone-Rules: Rel. Alloc. | Outages | Stor. Credit | Dec. Sched. | **Projected Elev.**

- Top of Dam
- Below Top of Dam
  - Min Flow
  - peaking power\_2
  - Bass spawning
    - IF (5/21-6/30)
      - Current Elevation
        - F (elev>=645)**
        - 2 ft decreasing rate
        - ELSE (elev<645)
        - zero decreasing rate
- Conservation
  - Min Flow
  - peaking power
  - Bass spawning
  - Inactive

Operates Release From: Comerford-Power Plant

IF Conditional:     Description:

Value1		Value2
Comerford-Pool:Elevation	>=	645

Logical Operator:

Value 1:

Operator:

Value 2:

---

Operation Set: Existing Ops    Description:

Zone-Rules: Rel. Alloc. | Outages | Stor. Credit | Dec. Sched. | **Projected Elev.**

- Top of Dam
- Below Top of Dam
  - Min Flow
  - peaking power\_2
  - Bass spawning
    - IF (5/21-6/30)
      - Current Elevation
        - IF (elev>=645)
          - 2 ft decreasing rate**
        - ELSE (elev<645)
          - zero decreasing rate
  - Conservation
    - Min Flow
    - peaking power
    - Bass spawning
    - Inactive

Operates Release From: Comerford

Elevation Rate of Change Limit:

Description:

Function Of:

Type:

Instantaneous  
 Period Average

Max Rate of Change (ft/hr):

Operation Set Existing Ops Description

Zone-Rules Rel. Alloc. Outages Stor. Credit Dec. Sched. Projected Elev

Top of Dam  
 Below Top of Dam  
 Min Flow  
 peaking power\_2  
 Bass spawning  
 IF (5/21-6/30)  
 Current Elevation  
 IF (elev>=645)  
 2 ft decreasing rate  
 ELSE (elev<645)  
 zero decreasing rate  
 Conservation  
 Min Flow  
 peaking power  
 Bass spawning  
 Inactive

Operates Release From: Comerford  
 ELSE Conditional elev<645 Description:

---

Operation Set Existing Ops Description

Zone-Rules Rel. Alloc. Outages Stor. Credit Dec. Sched. Projected Elev

Top of Dam  
 Below Top of Dam  
 Min Flow  
 peaking power\_2  
 Bass spawning  
 IF (5/21-6/30)  
 Current Elevation  
 IF (elev>=645)  
 2 ft decreasing rate  
 ELSE (elev<645)  
 zero decreasing rate  
 Conservation  
 Min Flow  
 peaking power  
 Bass spawning  
 Inactive

Operates Release From: Comerford  
 Elevation Rate of Change Limit zero decreasing rate  
 Description  
 Function Of: Constant  
 Type Decreasing  
 Instantaneous  
 Period Average  
 Max Rate of Change (ft/hr) 0.0

Figure 10: Reservoir Editor: Operations Tab – Existing Ops OpSet – Bass spawning

# Conant Brook

## I. Overview

Designed and constructed by the United States Army Corps of Engineers, this dam reduces flooding along the Quaboag, Chicopee, and Connecticut rivers. Construction of the project began in 1964 with completion in 1966. The Conant Brook Dam is located within the Chicopee River watershed. Unlike the other Corps operated flood control dams, Conant Brook is a completely uncontrolled structure..

Figure 1 shows the location of Conant Brook Dam as it is represented in the HEC-ResSim model. Figure 2 shows an aerial photo of the dam.

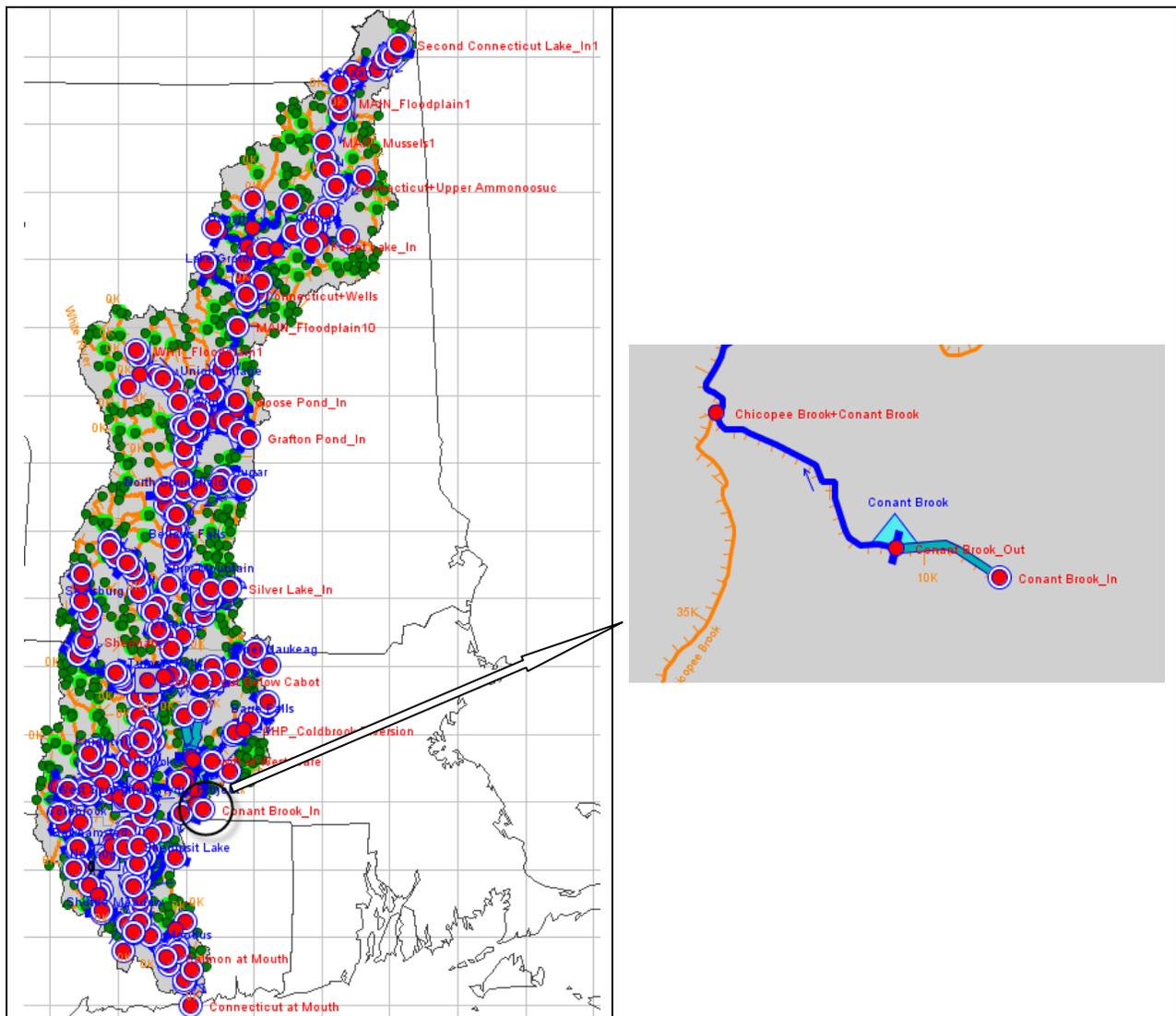


Figure 1: HEC-ResSim Map Display Showing Location of Conant Brook



**Figure 2: Aerial photo of Conant Brook Dam**

## **II. Physical Characteristics**

The physical characteristics of the reservoir are separated between the Pool and the Dam in the HEC-ResSim model. The elevation-storage-area defines the pool as shown in Figure 3. The dam consists of an uncontrolled spillway and uncontrolled 36-inch un-gated conduit as shown in Figure 4. All physical and operations data were provided by US Army Corps New England District, through both a previously created ResSim model and the Reservoir Regulation Team website<sup>22</sup>.

---

<sup>22</sup> [http://rsgisias.crrel.usace.army.mil/nae/cwms\\_map.map\\_index](http://rsgisias.crrel.usace.army.mil/nae/cwms_map.map_index)

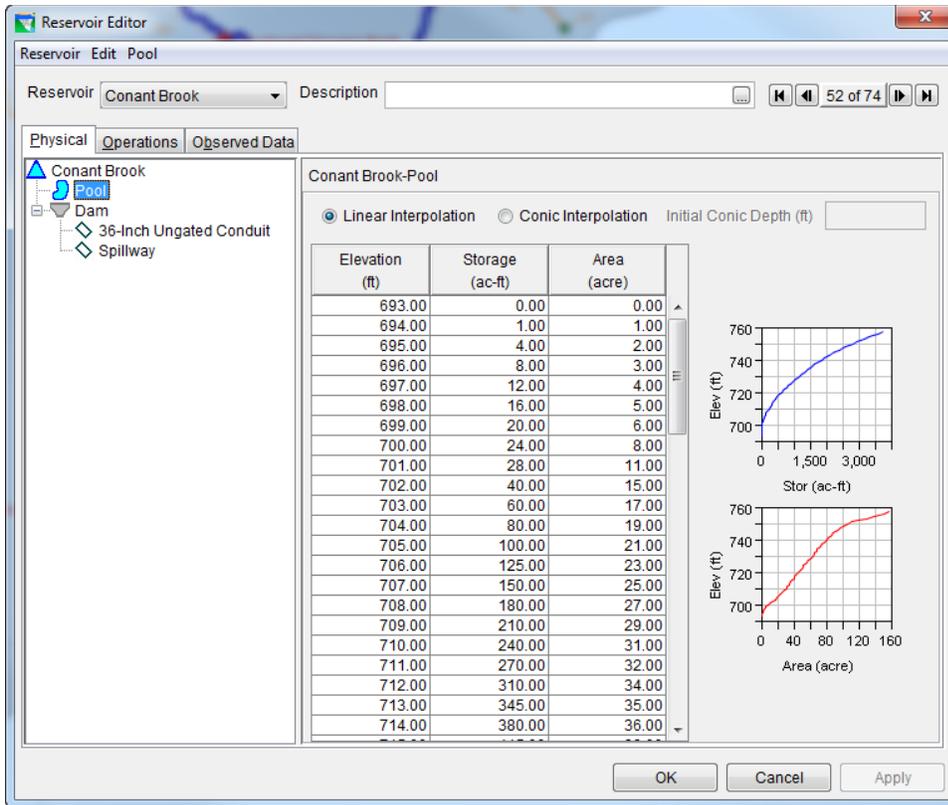


Figure 3: Reservoir Editor -- Physical Tab -- Pool

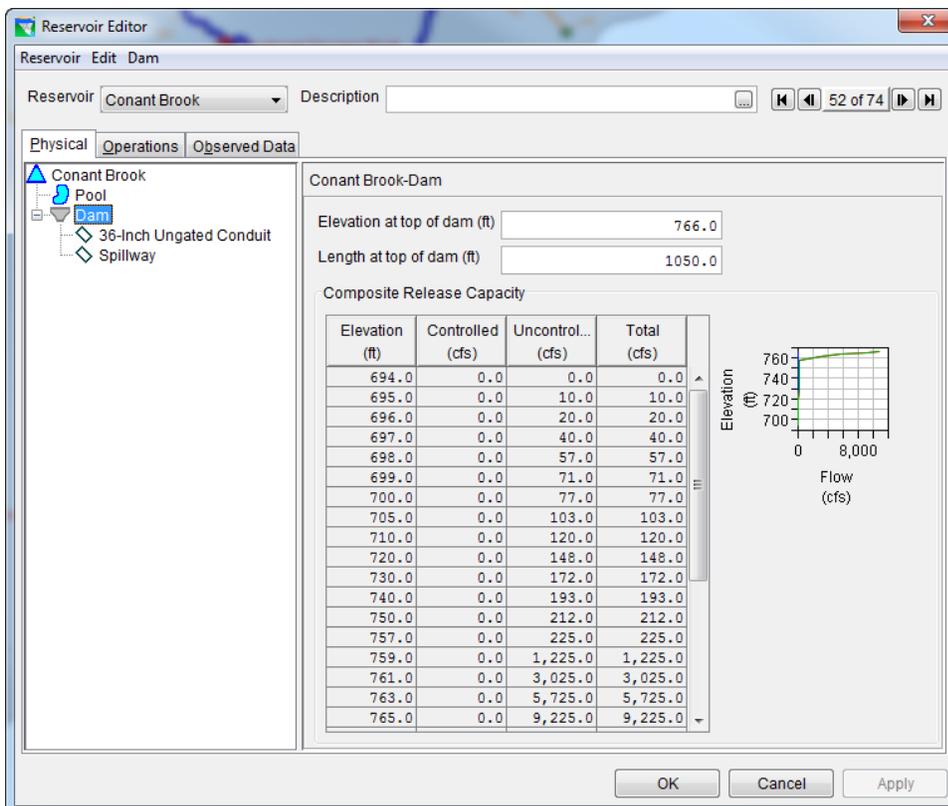


Figure 4: Reservoir Editor -- Physical Tab -- Dam



## Crescent Street

### I. Overview

Crescent Street dam is a dam on the Millers River in Athol, MA. It is owned and operated by the L.S. Starrett Company and is used for hydropower generation.

Figure 1 shows the location of Crescent Street Dam as it is represented in the HEC-ResSim model. Figure 2 shows a photo of the dam.

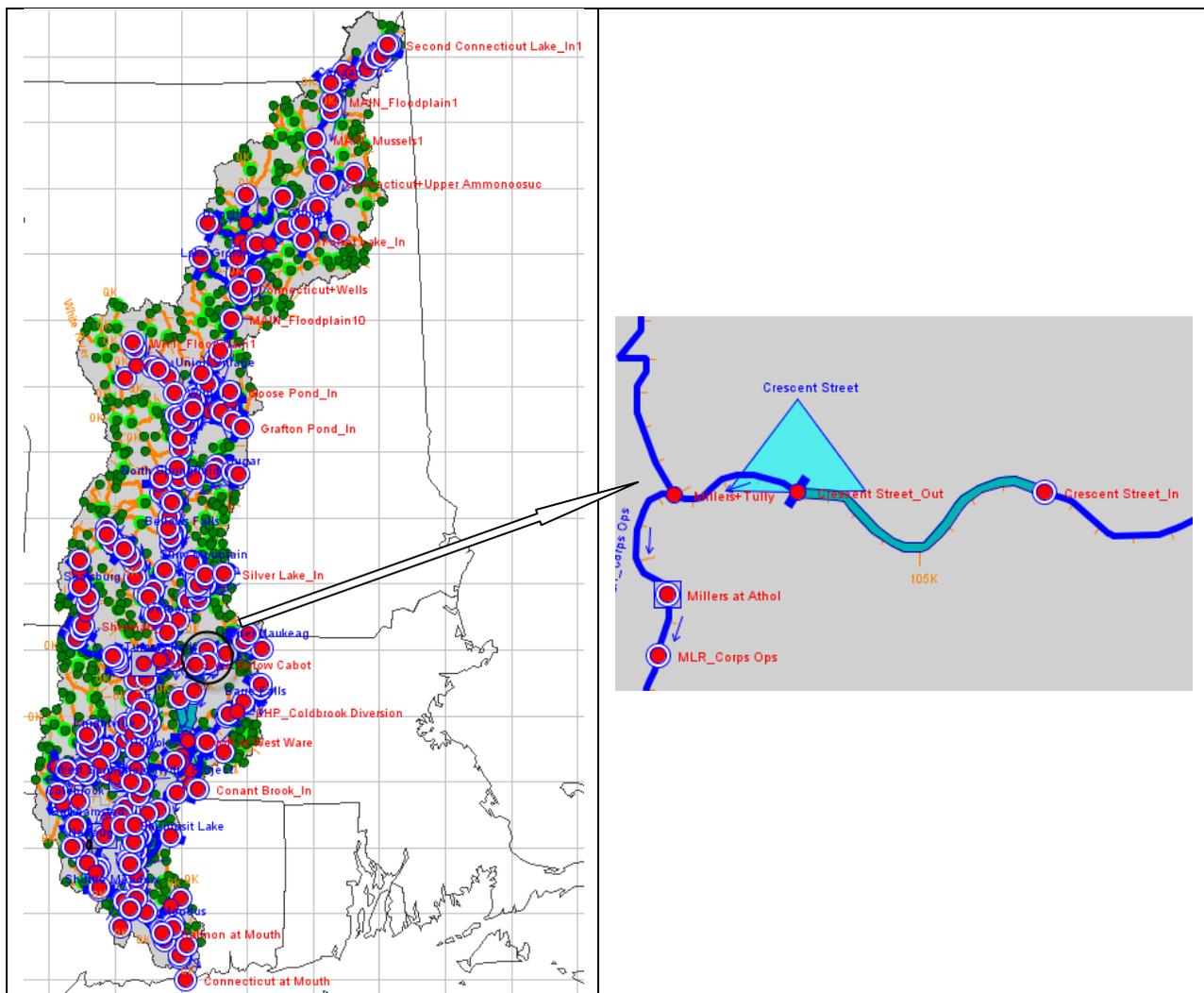


Figure 1: HEC-ResSim Map Display Showing Location of Crescent Street Dam



Figure 2: Photo of Crescent Street Dam

## II. Physical Characteristics

The physical characteristics of the reservoir are separated between the Pool and the Dam in the HEC-ResSim model. The elevation-storage-area defines the pool as shown in Figure 3<sup>23</sup>. The dam consists of three types of outlets: (1) an uncontrolled Main spillway, (2) an uncontrolled outlet, and (3) a power plant as shown in Figure 4. The power plant has a maximum capacity of 510 cfs. The dam has a constant tailwater elevation of 523.4 feet.

---

<sup>23</sup> National Dam Inspection Program. Phase I Inspection Report. 1972.





# Crystal Lake

## I. Overview

Crystal Lake dam is located in the town of Enfield, NH and flows into the Mascoma River. The dam is maintained and operated by the State of New Hampshire Water Resources Board and is used primarily to provide a recreational lake with some flood control benefits.

Figure 1 shows the location of Crystal Lake as it is represented in the HEC-ResSim model. Figure 2 shows a photo of Crystal Lake.

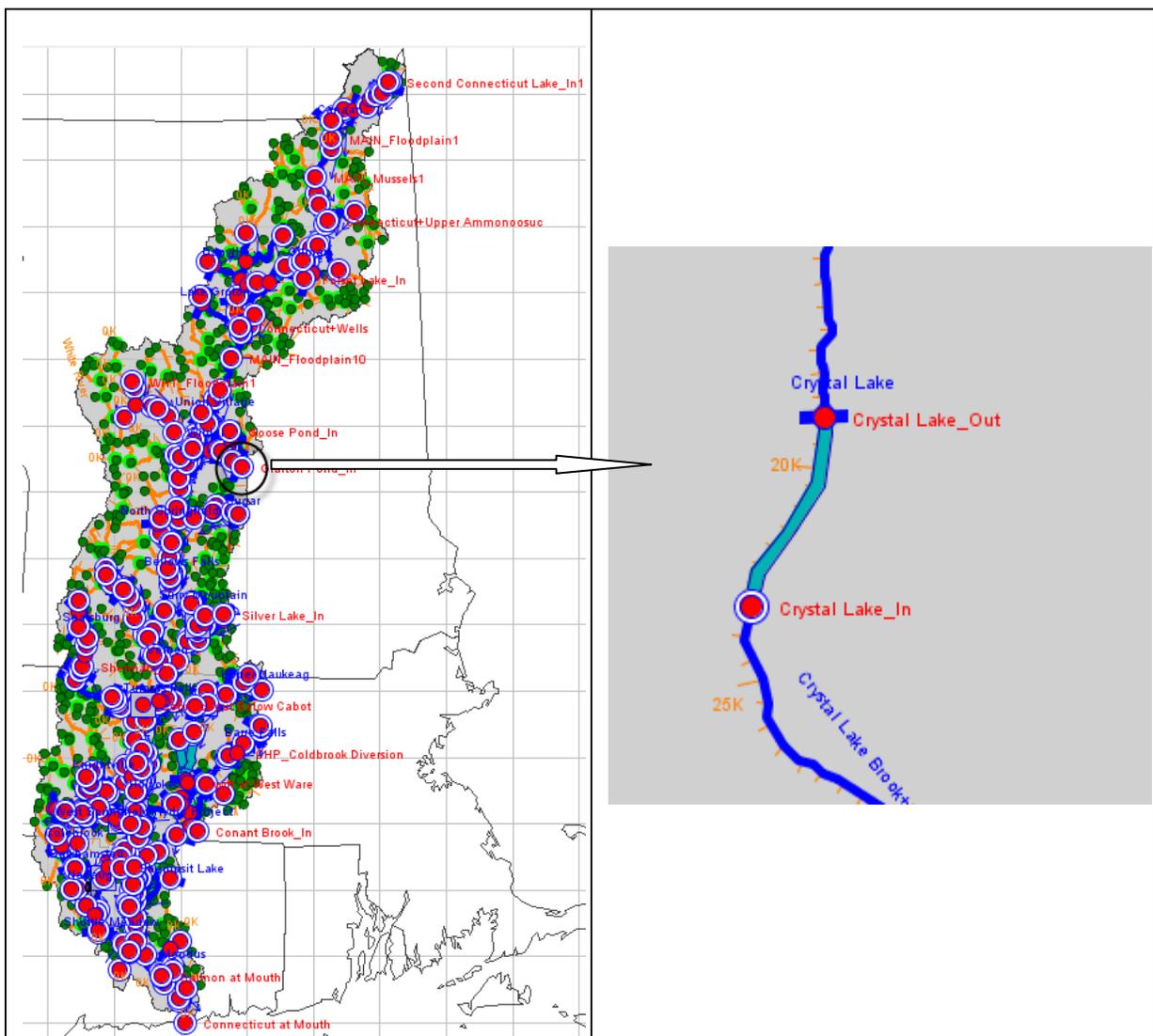


Figure 1: HEC-ResSim Map Display Showing Location of Crystal Lake



Figure 2: Photo of Crystal Lake

## II. Physical Characteristics

The physical characteristics of the reservoir are separated between the Pool and the Dam in the HEC-ResSim model. The elevation-storage-area defines the pool as shown in Figure 3<sup>24</sup>. The dam consists of two types of outlets: (1) uncontrolled stoplogs, (2) uncontrolled spillway as shown in Figure 4<sup>25</sup>.

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<sup>24</sup>NHSDam Data Sheet. Crystal Lake. 2006.

<sup>25</sup>National Dam Inspection Program. Phase I Inspection Report: Crystal Lake Dam. 1978

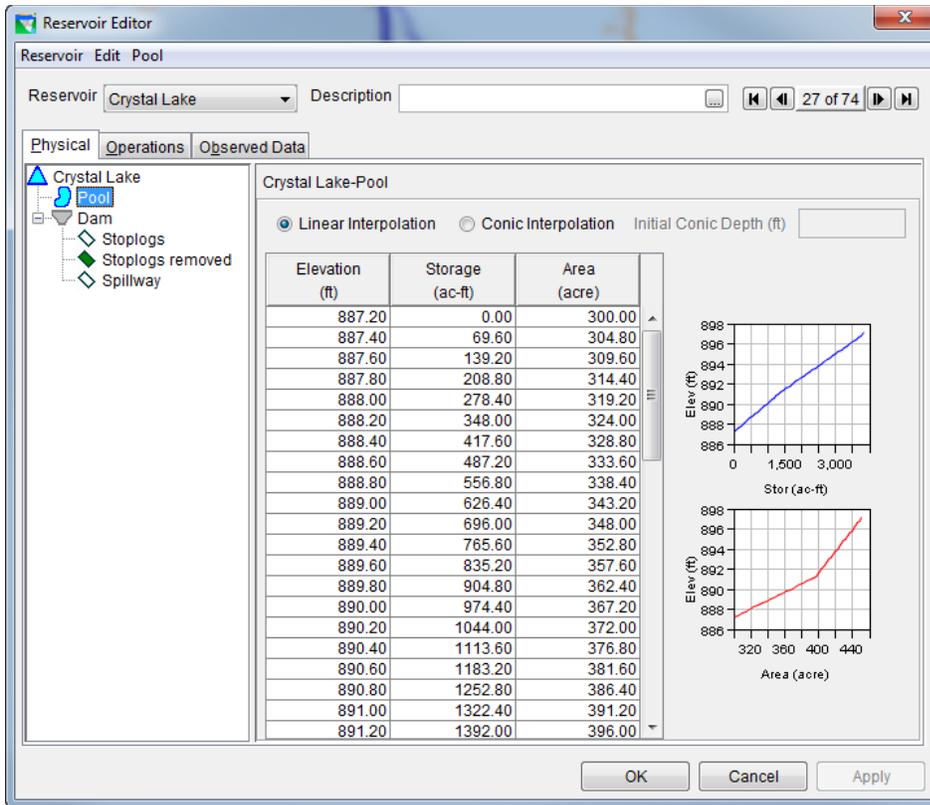


Figure 3: Reservoir Editor -- Physical Tab -- Pool

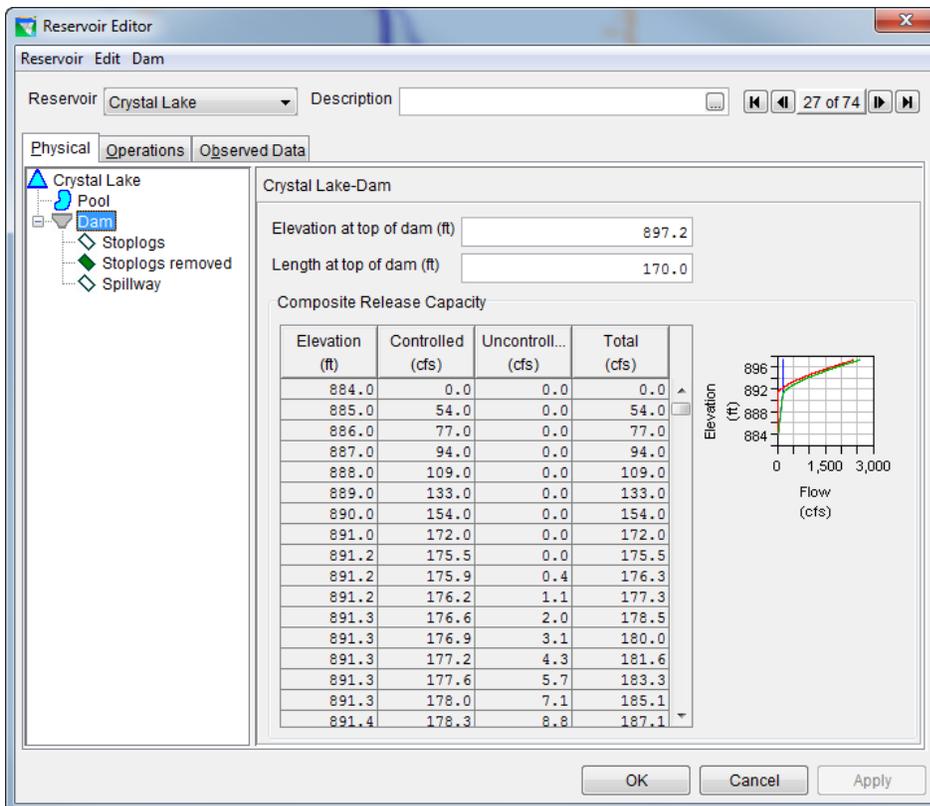


Figure 4: Reservoir Editor -- Physical Tab -- Dam



## B. Rule Illustrations

Figure 5 shows a set of operational rules specified for each zone that reflects the operation set named Existing Ops.

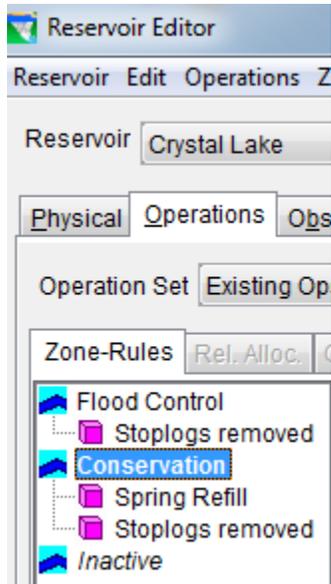


Figure 5: Reservoir Editor -- Operations Tab -- Existing Ops OpSet -- Zones and Rules

## C. Rule Descriptions

### 1. Stoplogs removed

Figure 6 shows the content of “Stoplogs removed” rule. This rule defines the maximum release from a controlled gate when stoplogs are removed as a function of pool elevation.

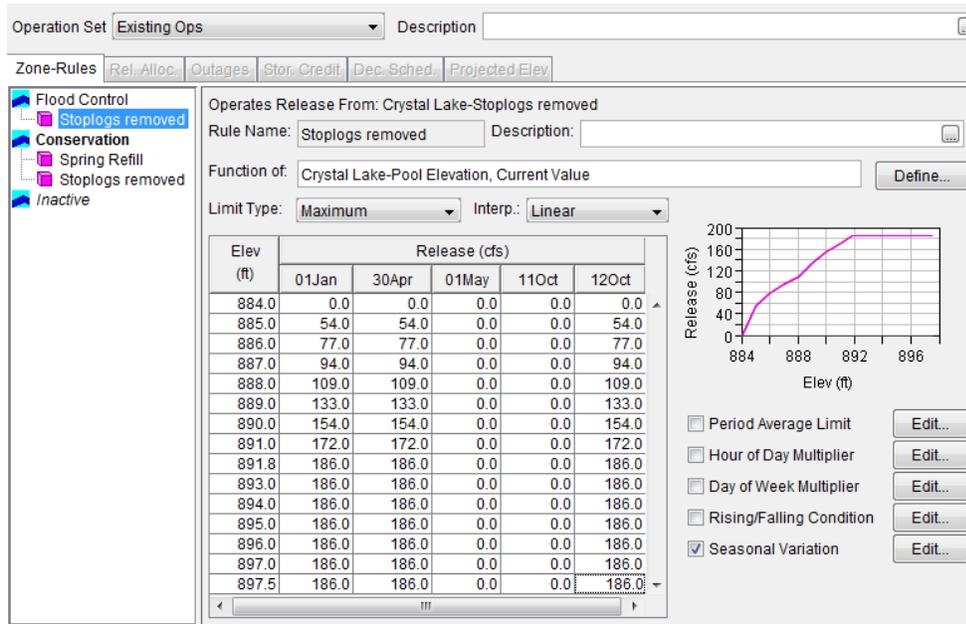


Figure 6: Reservoir Editor -- Operations Tab – Existing Ops OpSet – Stoplogs removed

### 2. Spring Refill

Figure 7 shows the content of “Spring Refill” rule. This rule defines the maximum seasonal release as a function of Inflow.

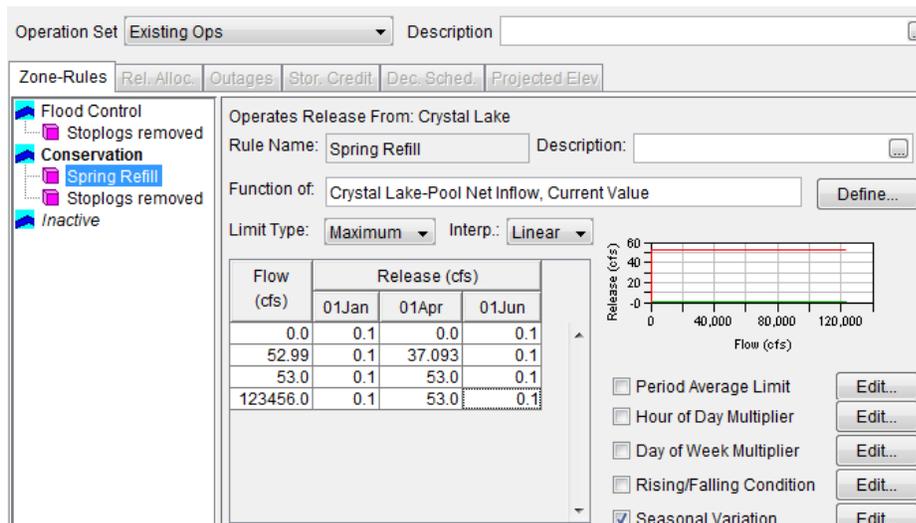


Figure 7 Reservoir Editor: Operations Tab – Existing Ops OpSet – Spring Refill

# Danville

## I. Overview

Constructed in 1916, Green Mountain Power Corporation (GMP) owns and operates the West Danville Dam and hydroelectric generating facility (Station No. 15) located on Joe’s Brook in Caledonia County, Vermont. The dam itself creates Joes Pond.

Figure 1 shows the location of Danville Dam as it is represented in the HEC-ResSim model. Figure 2 shows a photo of Danville Dam.

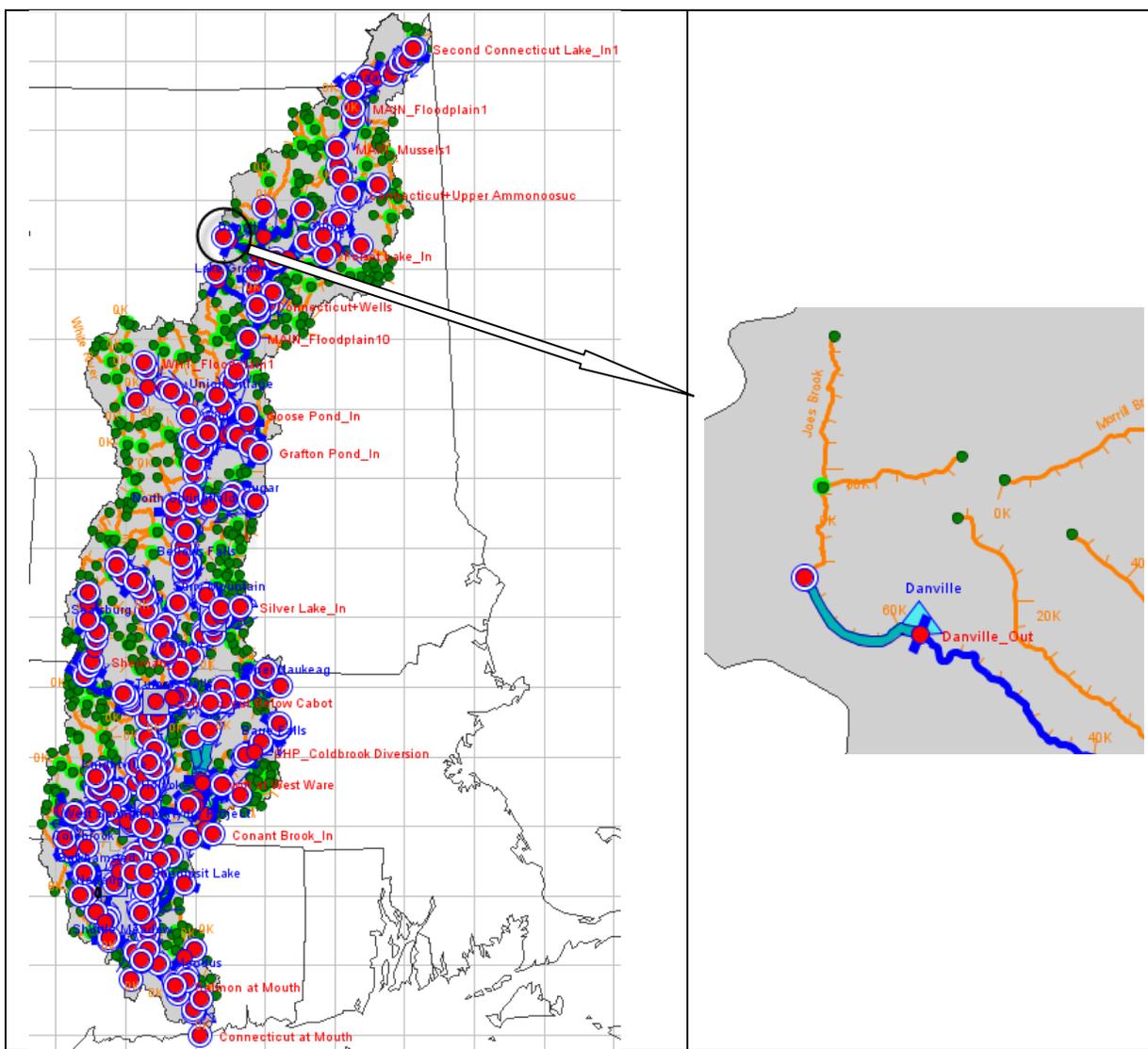


Figure 1 HEC-ResSim Map Display Showing Location of Danville



**Figure 2: Photo of Joes Pond, which is impounded by the West Danville Dam**

## **II. Physical Characteristics**

The physical characteristics of the reservoir are separated between the Pool and the Dam in the HEC-ResSim model. The elevation-storage-area defines the pool as shown in Figure 3<sup>26</sup>. The dam consists of two types of outlets: (1) controlled sluice gate, and (2) power plant as shown in Figure 4<sup>1,27</sup>.

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<sup>26</sup> National Inventory of Dams database

<sup>27</sup> Green Mountain Power Corporation. Operating Plan for the West Danville Project. 2005.





## B. Rule Illustrations

Figure 6 shows a set of operational rules specified for each zone that reflects the operation set named Existing Ops.

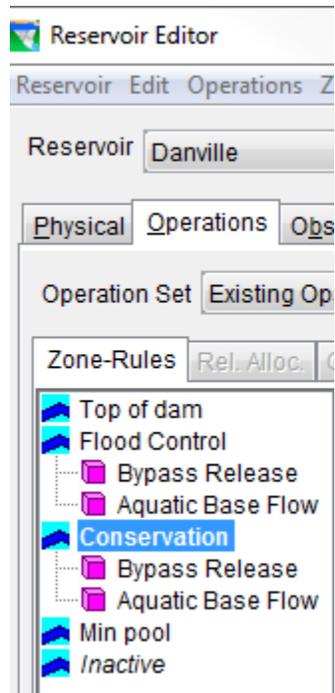


Figure 6: Reservoir Editor -- Operations Tab -- Existing Ops OpSet -- Zones and Rules



## Deerfield No. 2 Development

### I. Overview

Deerfield No. 2 Development is located downstream of Shelburne Falls on the Deerfield River and is the closest counting up from confluence with the Connecticut River. It is owned and operated by TransCanada Hydro Northeast Inc. for hydropower generation on a run-of-river basis.

Figure 1 shows the location of Deerfield No. 2 dam as it is represented in the HEC-ResSim model, and Figure 2 shows a photo from Deerfield No.2 dam.

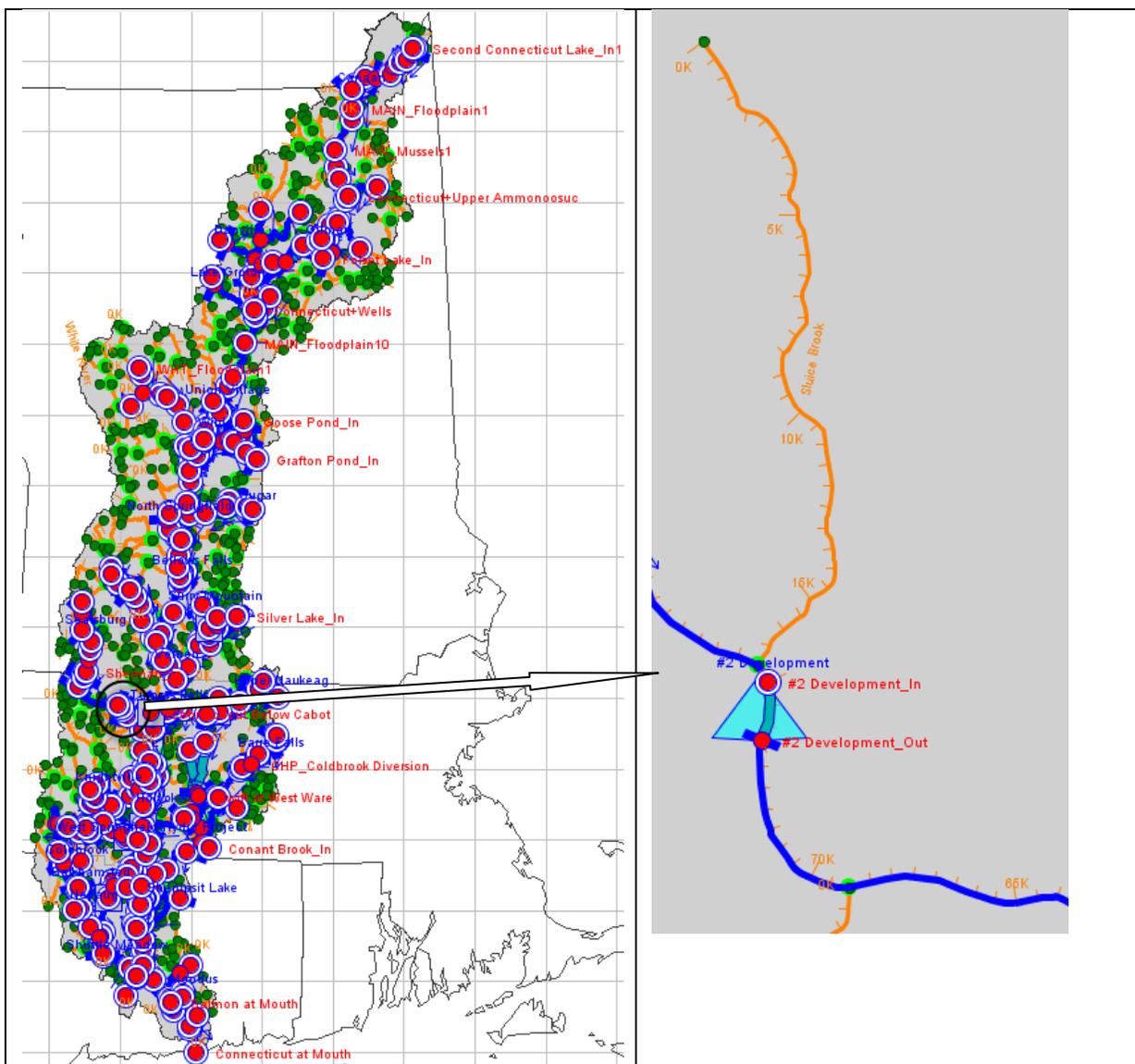


Figure 1: HEC-ResSim Map Display Showing Location of Deerfield No.2



Figure 2: Photo of Deerfield No. 2 Dam

## II. Physical Characteristics

The physical characteristics of the reservoir are separated between the Pool and the Dam in the HEC-ResSim model. The elevation-storage-area defines the pool as shown in Figure 3<sup>28</sup>. The dam consists of three types of outlets: (1) controlled spillway, (2) controlled sluice, and power plant as shown in Figure 4 (TransCanada Corporation).

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<sup>28</sup> Data provided by TransCanada





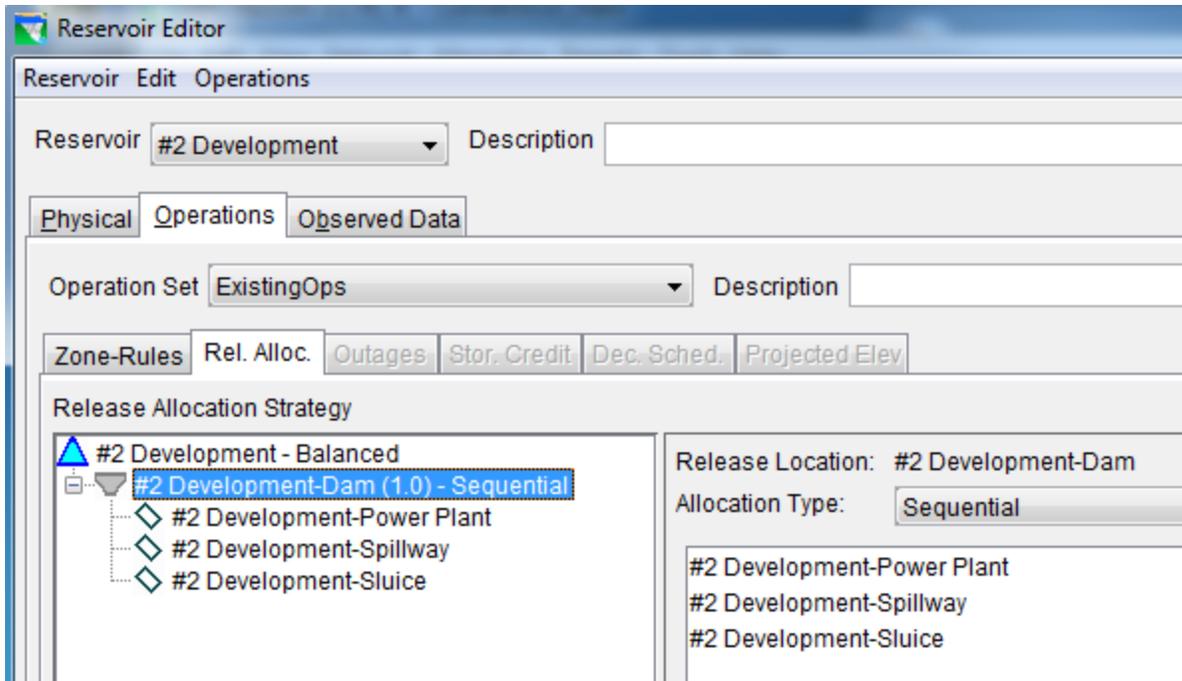


Figure 6: Reservoir Editor: Operations Tab – Existing Ops OpSet – Release Allocation

## B. Rule Illustrations

Figure 7 shows a set of operational rules specified for each zone that reflects the operation set named Existing Ops<sup>29</sup>.

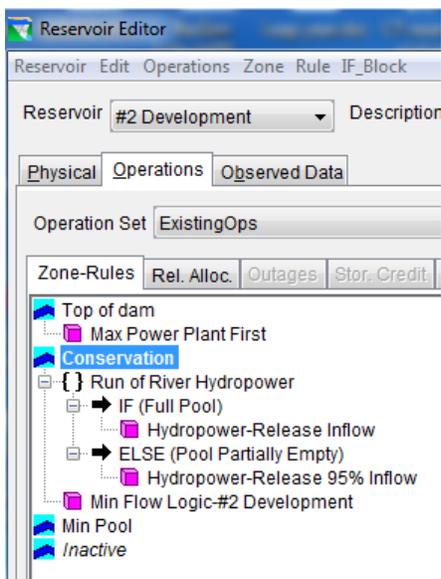


Figure 7: Reservoir Editor: Operations Tab – Existing Ops OpSet – Zones and Rules

<sup>29</sup> TransCanada. Deerfield River Operational Constraints. 2012.

## C. Rule Descriptions

### 1. Max Power Plant First

Figure 8 shows the content of “Max Power Plant First” rule. This rule forces the inflow to pass through the power plant first until it reaches the maximum plant capacity.

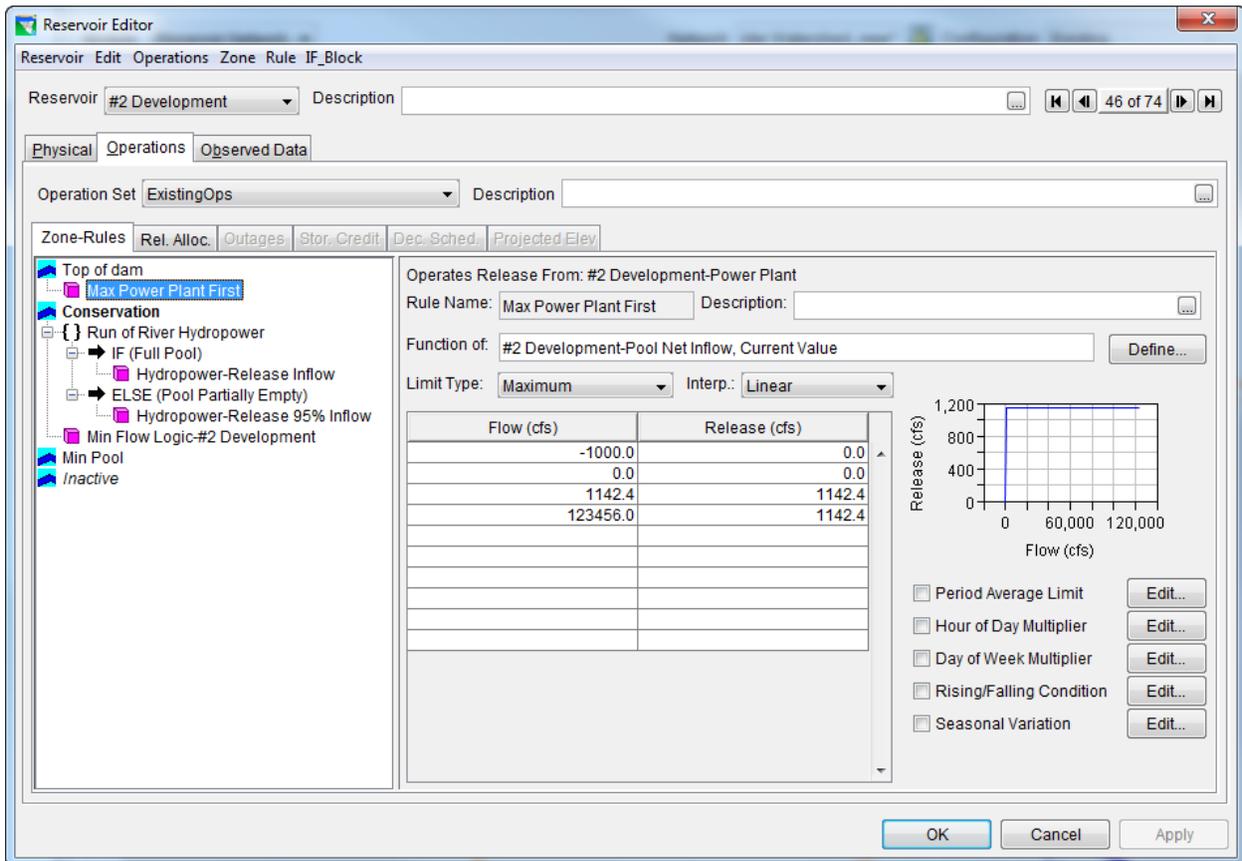


Figure 8 Reservoir Editor: Operations Tab – Existing Ops OpSet – Max Power Plant First

## 2. Run of River Hydropower

Figure 9 shows the content of “Run of River Hydropower” rule. This rule release total inflow through power plant when pool elevation is higher than conservation elevation and 95% of inflow when pool elevation is less than conservation zone as per the run-of-river modeling strategy.

The screenshot displays two panels of a software interface for configuring a rule. Both panels show the 'Operation Set' as 'ExistingOps' and the 'Description' field empty.

**Top Panel:** The 'Zone-Rules' tab is active. The left sidebar shows a tree view with 'Run of River Hydropower' expanded to 'IF (Full Pool)'. The main area shows 'Operates Release From: #2 Development-Power Plant'. The 'IF Conditional' is 'Full Pool' with a description field. A table below shows the conditional logic:

Value1	Operator	Value2
#2 Development-Pool:Elevation	>=	294.6

Buttons for 'Add Cond.', 'Del. Cond.', 'Move Up', and 'Move Down' are visible.

**Bottom Panel:** The 'Zone-Rules' tab is active. The left sidebar shows 'Run of River Hydropower' expanded to 'Hydropower-Release Inflow'. The main area shows 'Operates Release From: #2 Development-Power Plant'. The 'Rule Name' is 'ydropower-Release Inflow' with a description field. The 'Function of' is '#2 Development-Pool Net Inflow, Current Value' with a 'Define...' button. The 'Limit Type' is 'Mi...' and 'Interp.' is '-'. A table below shows the release logic:

Flow (cfs)	Release (cfs)
0.0	0.0
10000.0	10000.0

To the right of the table is a graph showing 'Release (cfs)' on the y-axis (0 to 12,000) and 'Flow (cfs)' on the x-axis (0 to 10,000). A blue line represents the release function, which is a straight line from (0,0) to (10,000, 10,000). Below the graph are several checkboxes: 'Period Average Limit', 'Hour of Day Multiplier', 'Day of Week Multiplier', 'Rising/Falling Condition', and 'Seasonal Variation', each with an 'Edit...' button.



### 3. Min Flow Logic#2 Development

Figure 10 shows the content of Min Flow Log#2 Development. This rule represents the minimum flow of 200 cfs from Deerfield #2.

The screenshot displays the 'Operations Tab' in the Reservoir Editor. The 'Operation Set' is 'ExistingOps'. The 'Zone-Rules' pane on the left shows a tree structure with 'Min Flow Logic-#2 Development' selected. The main configuration area shows the rule name and function, and a table for release limits.

Operates Release From: #2 Development  
 Rule Name: **ow Logic-#2 Development** Description:

Function of:

Limit Type: **Minimum** Interp.: **Linear**

Date	Release (cfs)
01Jan	200.0

Release (cfs) graph showing a constant value of 200.0 from Jan to Nov.

Period Average Limit   
 Hour of Day Multiplier   
 Day of Week Multiplier   
 Rising/Falling Condition   
 Seasonal Variation

Figure 10: Reservoir Editor: Operations Tab – Existing Ops OpSet – Min Flow Logic #2 Development

## Deerfield No. 3 Development

### I. Overview

Deerfield No. 3 Development is located on the Deerfield River upstream from Selburne Falls, MA. It is owned and operated by TransCanada Hydro Northeast Inc for hydropower generation on a run-of-river basis.

Figure 1 shows the location of Deerfield No. 3 dam as it is represented in the HEC-ResSim model. Figure 2 shows a photo of Deerfield No. 3 dam

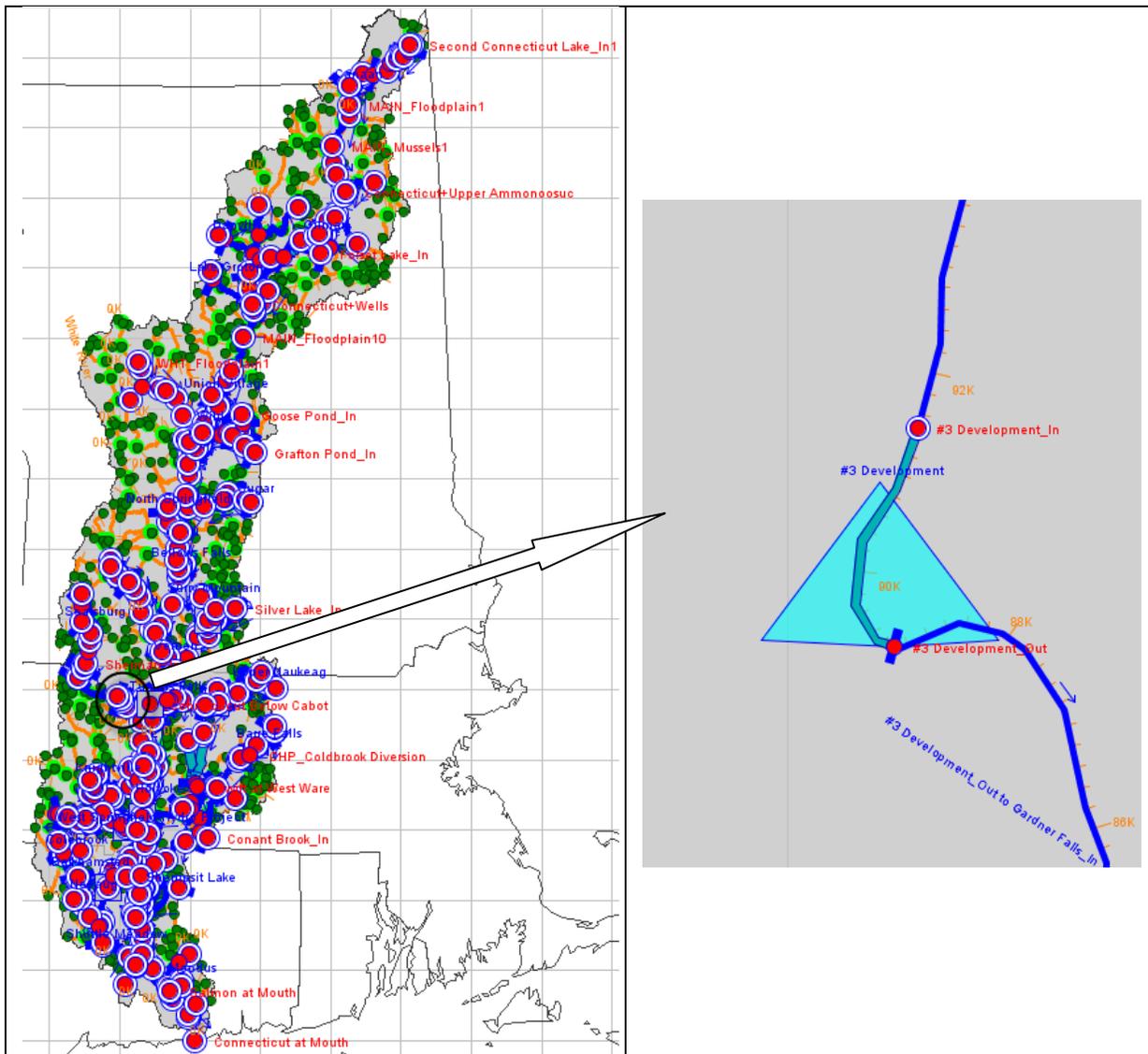


Figure 1: HEC-ResSim Map Display Showing Location of Deerfield No. 3



Figure 2: Photo of Deerfield No. 3 Development

## II. Physical Characteristics

The physical characteristics of the reservoir are separated between the Pool and the Dam in the HEC-ResSim model. The elevation-storage-area defines the pool as shown in Figure 3<sup>30</sup>. The dam consists of four types of outlets: (1) controlled sluice, (2) controlled old fish gate, (3) uncontrolled flashboard spillway, and (4) power plant as shown in Figure 4.

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<sup>30</sup> Data provided by TransCanada

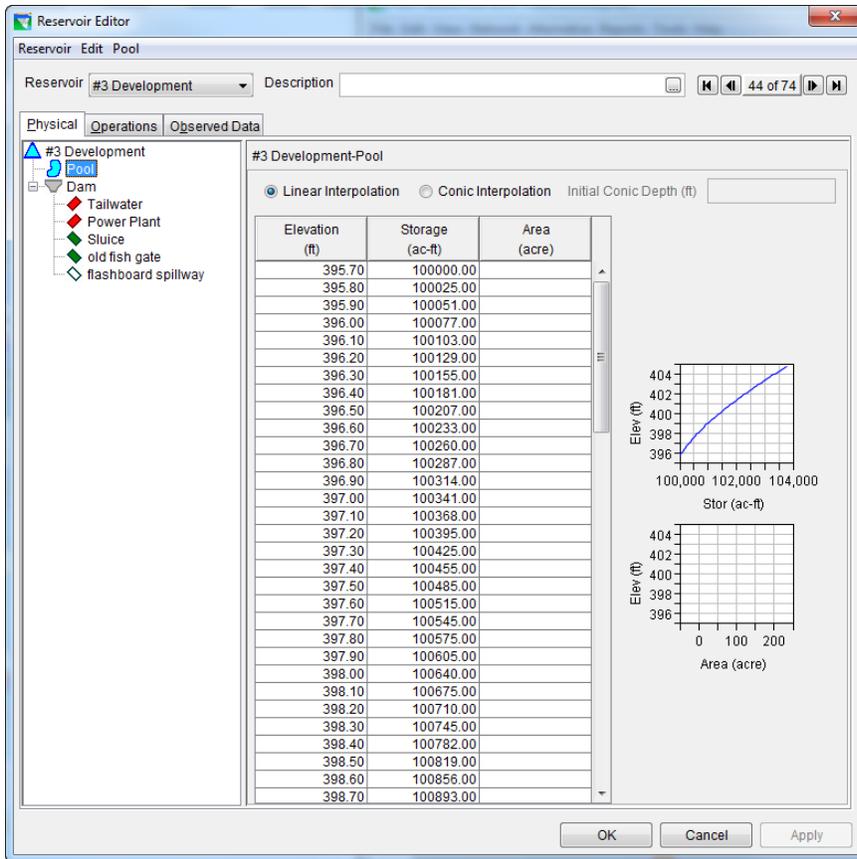


Figure 3: Reservoir Editor: Physical Tab -- Pool

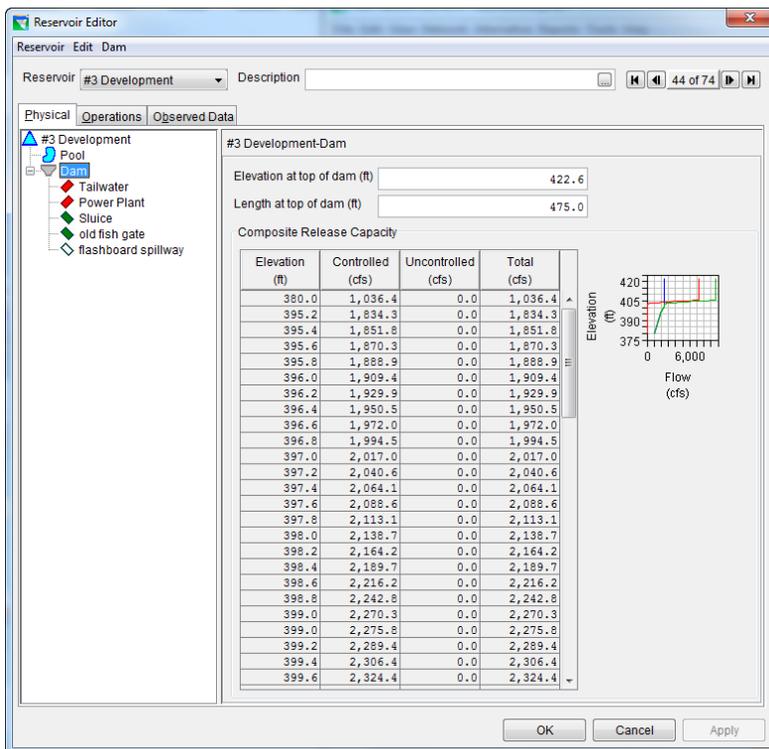


Figure 4: Reservoir Editor: Physical Tab -- Dam



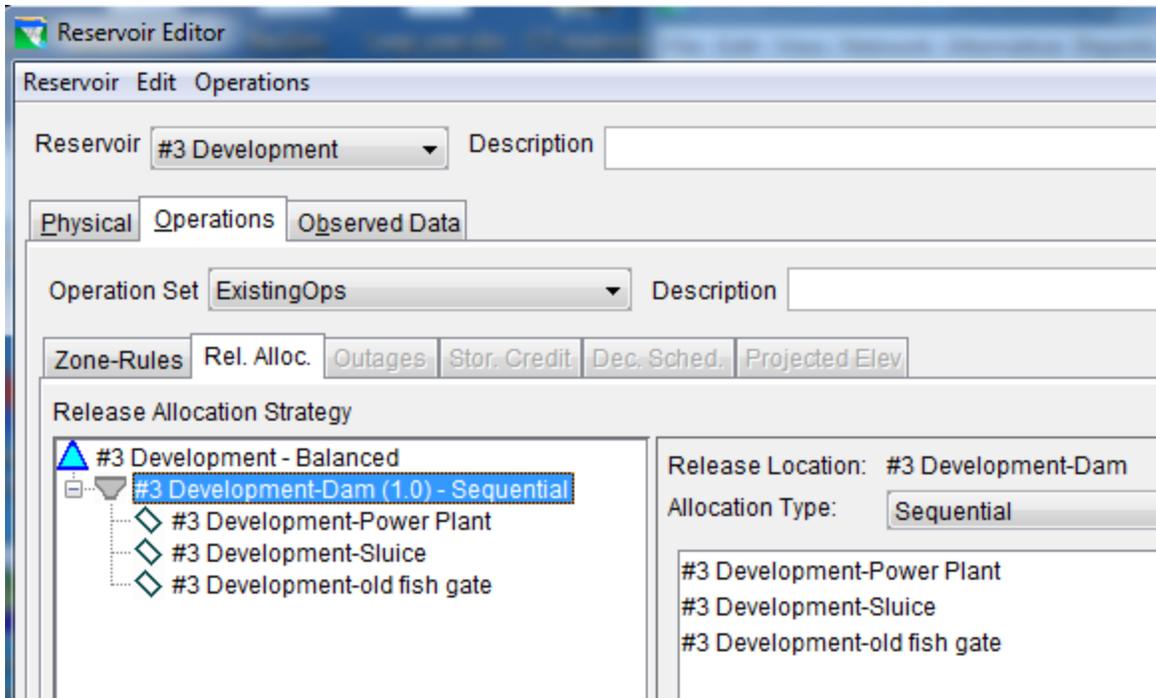


Figure 6: Reservoir Editor: Operations Tab – Existing Ops OpSet – Release Allocation

## B. Rule Illustrations

Figure 7 shows a set of operational rules specified for each zone that reflects the operation set named Existing Ops<sup>31</sup>.

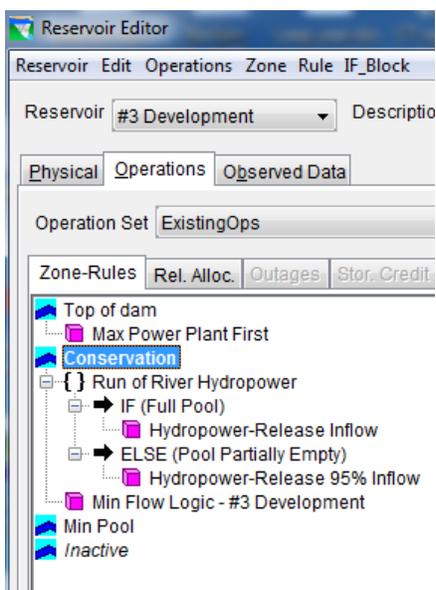


Figure 7: Reservoir Editor: Operations Tab – Existing Ops OpSet – Zones and Rules

<sup>31</sup> TransCanada. Deerfield River Operational Constraints. 2012.

## C. Rule Descriptions

### 1. Max Power Plant First

Figure 8 shows the content of “Max Power Plant First” rule. This rule forces the inflow to pass through the power plant first until it reaches the maximum plant capacity.

The screenshot displays the 'Reservoir Editor' interface. At the top, the 'Reservoir' is set to '#3 Development'. Below this, the 'Operations' tab is active, showing the 'ExistingOps' operation set. The 'Zone-Rules' section on the left lists various rules, with 'Max Power Plant First' selected. The main configuration area on the right shows the rule's details:

- Operates Release From:** #3 Development-Power Plant
- Rule Name:** Max Power Plant First
- Function of:** #3 Development-Pool Net Inflow, Current Value
- Limit Type:** Maxi... (Maximum)
- Interp.:** L... (Linear)

A table below the configuration shows the relationship between flow and release:

Flow (cfs)	Release (cfs)
-1000.0	0.0
0.0	0.0
1022.4	1022.4
123456.0	1022.4

To the right of the table is a graph with 'Flow (cfs)' on the x-axis (0 to 120,000) and 'Release (cfs)' on the y-axis (0 to 1,200). The graph shows a step function where release is 0 for flow up to 1022.4 cfs, and then jumps to 1022.4 cfs for any higher flow.

At the bottom right, there are several unchecked options with 'Edit...' buttons: Period Average Limit, Hour of Day Multiplier, Day of Week Multiplier, Rising/Falling Condition, and Seasonal Variation.

Figure 8: Reservoir Editor: Operations Tab – Existing Ops OpSet – Max Power Plant First

## 2. Run of River Hydropower

Figure 9 shows the content of “Run of River Hydropower” rule. This rule release total inflow through power plant when pool elevation is higher than conservation elevation and 95% of inflow when pool elevation is less than conservation zone as per the run-of-river modeling strategy.

The image displays two screenshots of a software interface for configuring rules. Both screenshots show the 'Operation Set' as 'ExistingOps' and the 'Description' field empty. The left sidebar shows a tree view of rules under 'Conservation', with 'Run of River Hydropower' expanded to show its sub-rules: 'IF (Full Pool)', 'Hydropower-Release Inflow', 'ELSE (Pool Partially Empty)', and 'Hydropower-Release 95% Inflow'. The right pane shows the configuration for the selected rule.

**Top Screenshot: IF (Full Pool) Configuration**

- Operates Release From: #3 Development-Power Plant
- IF Conditional: Full Pool
- Description: [Empty]
- Table:
 

Value1	Value2
#3 Development-Pool:Elevation	>= 402.6
- Buttons: Add Cond., Del. Cond., Move Up, Move Down, Evaluate

**Bottom Screenshot: ELSE (Pool Partially Empty) Configuration**

- Operates Release From: #3 Development-Power Plant
- ELSE Conditional: Pool Partially Empty
- Description: [Empty]

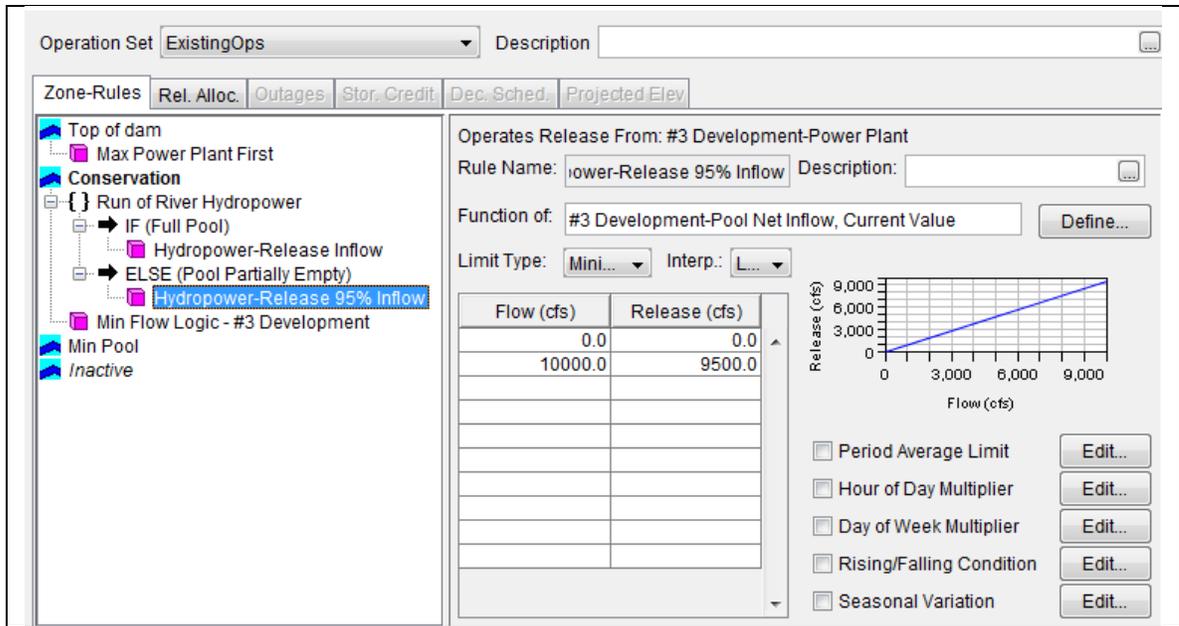


Figure 9: Reservoir Editor: Operations Tab – Existing Ops OpSet – Run of River hydropower

### 3. Min Flow Logic#3 Development

This rule represents seasonal minimum flow as represented in Figure 10.

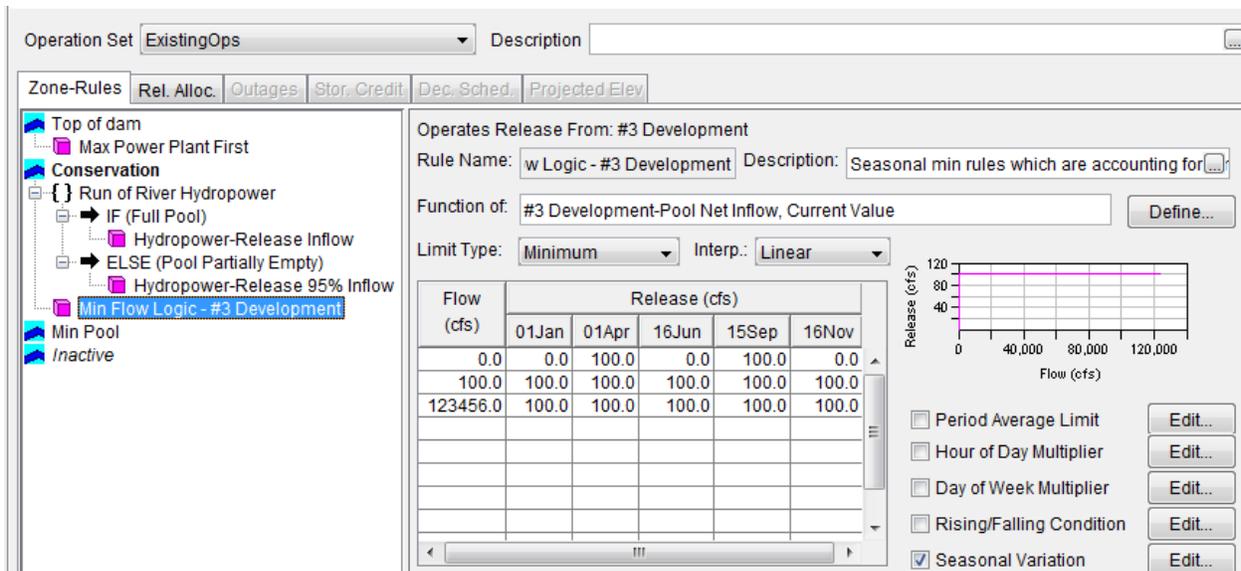


Figure 10: Reservoir Editor: Operations Tab – Existing Ops OpSet – Min Flow Logic #3 Development

## Deerfield No.4 Development

### I. Overview

Deerfield No. 4 Development is located directly downstream of the Highway 2 bridge on the Deerfield River. It is owned and operated by TransCanada Hydro Northeast Inc. for hydropower generation on a run-of-river basis.

Figure 1 shows the location of Deerfield No. 4 dam as it is represented in the HEC-ResSim model. Figure 2 shows a photo of Deerfield No. 4 dam.

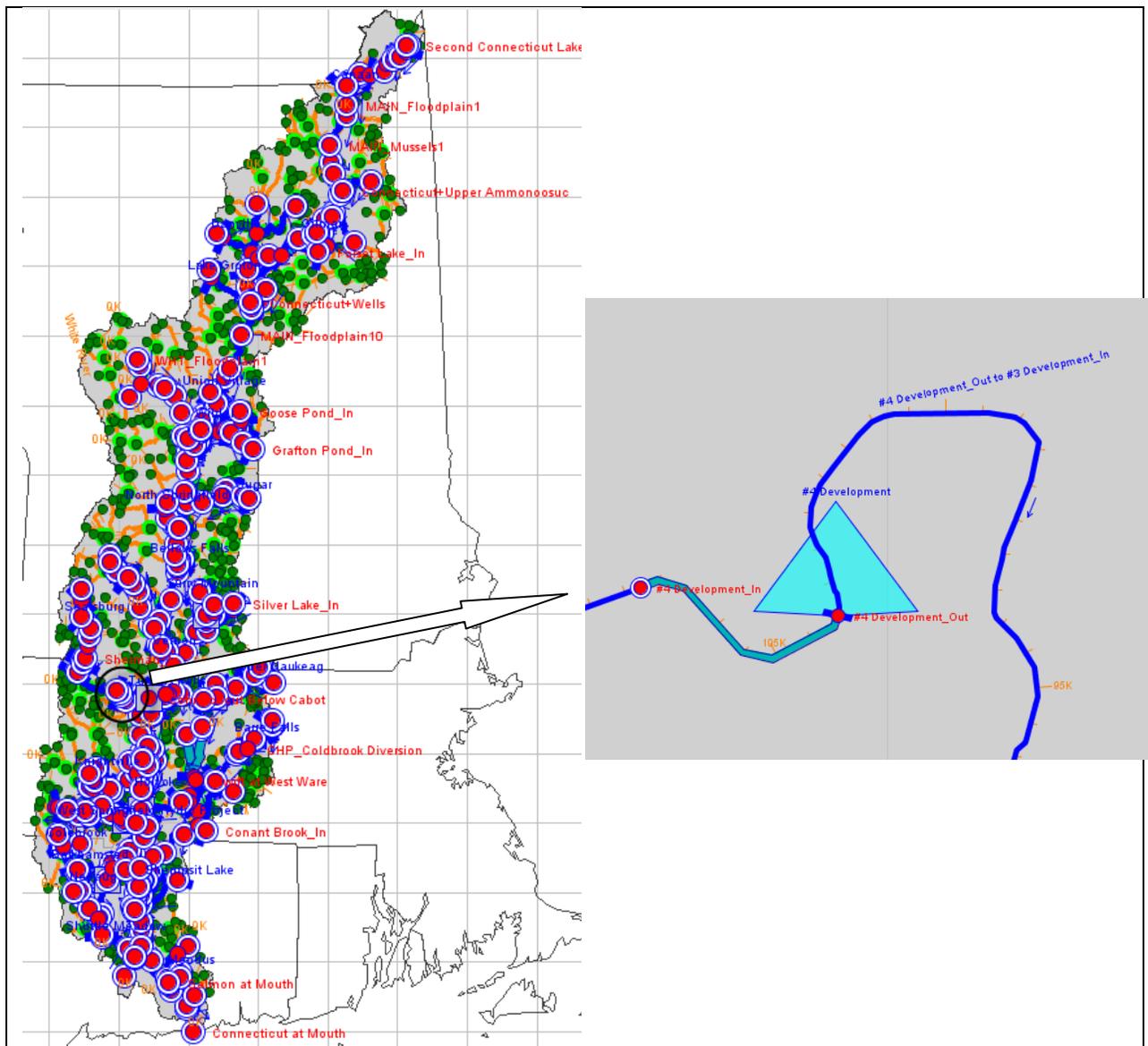


Figure 1: HEC-ResSim Map Display Showing Location of Deerfield No.4

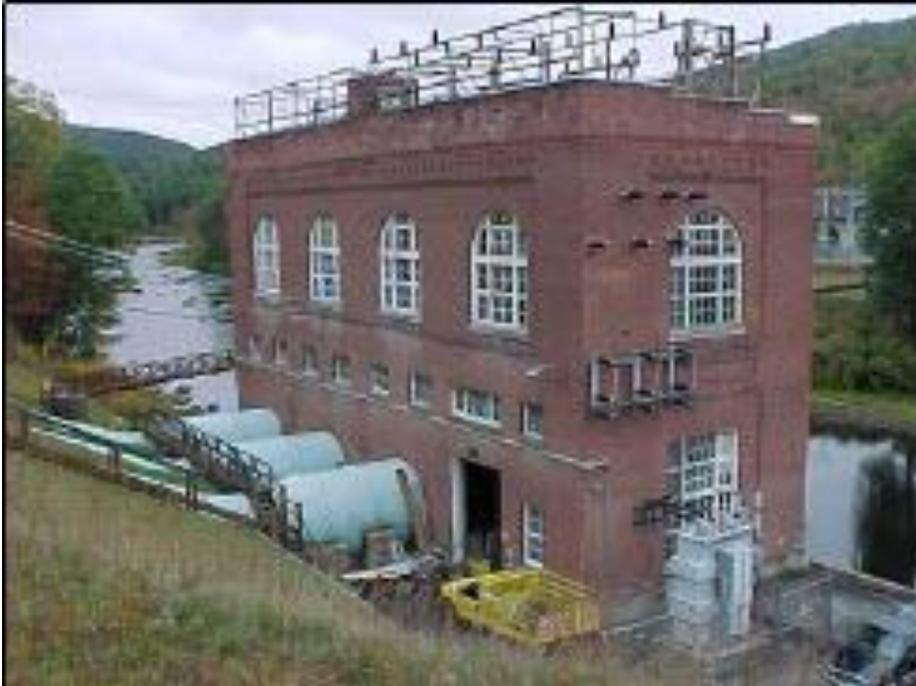


Figure 2: Photo of Deerfield No. 4 Development

## II. Physical Characteristics

The physical characteristics of the reservoir are separated between the Pool and the Dam in the HEC-ResSim model. The elevation-storage-area defines the pool as shown in Figure 3<sup>32</sup>. The dam consists of five types of outlets: (1) controlled fish gate, (2) controlled sluice No.1&2, (3) controlled sluice No.3, (4) uncontrolled flashboard spillway, and (5) power plant as shown in Figure 4.

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<sup>32</sup> Data provided by TransCanada

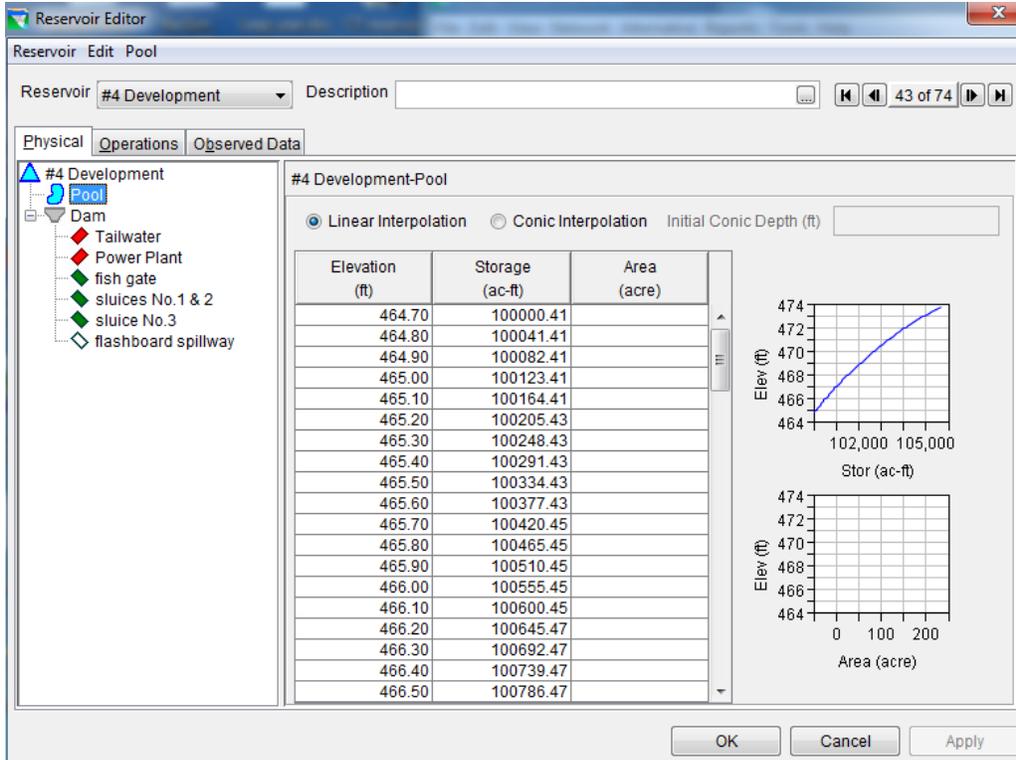


Figure 3: Reservoir Editor: Physical Tab -- Pool

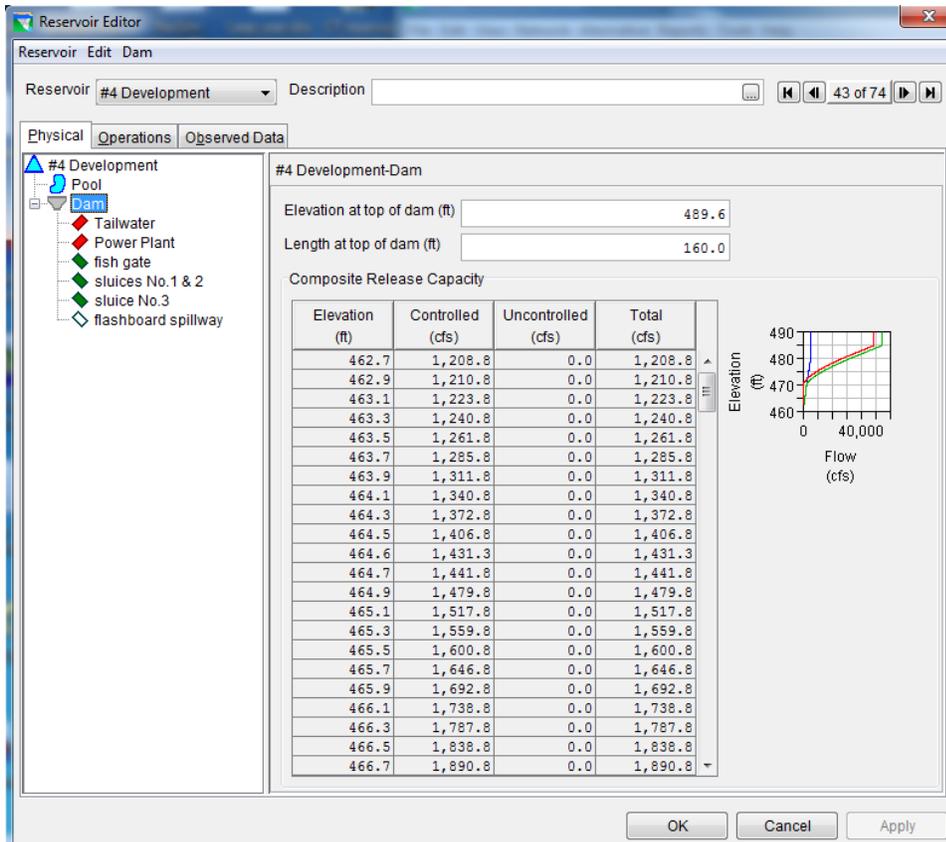


Figure 4: Reservoir Editor: Physical Tab -- Dam



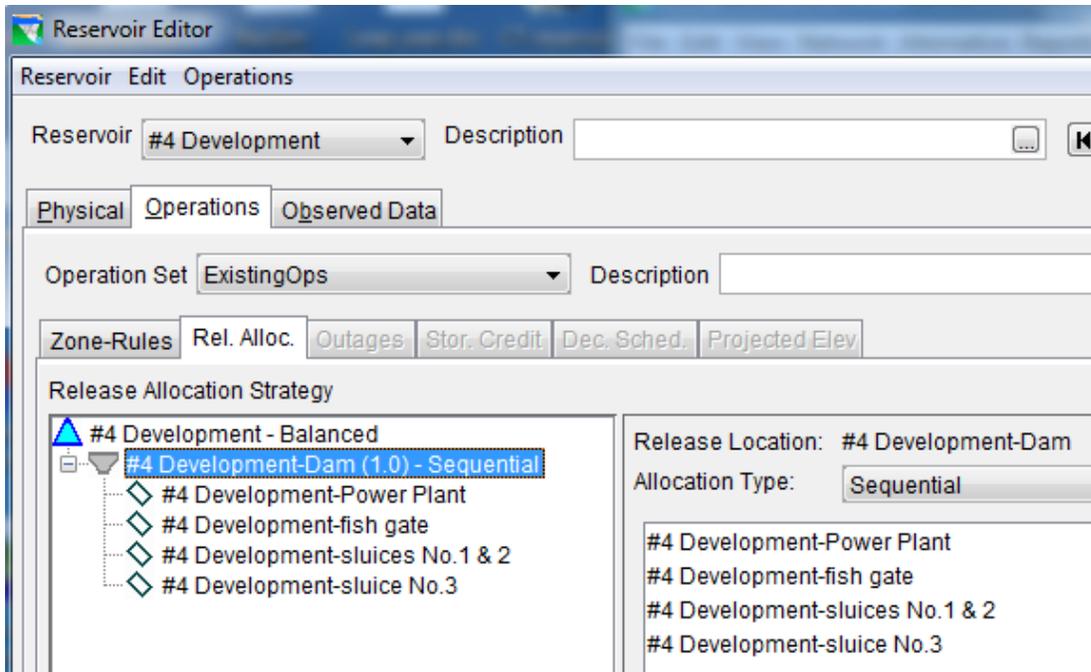


Figure 6: Reservoir Editor: Operations Tab – Existing Ops OpSet – Release Allocation

## B. Rule Illustrations

Figure 7 shows a set of operational rules specified for each zone that reflects the operation set named Existing Ops<sup>33</sup>.

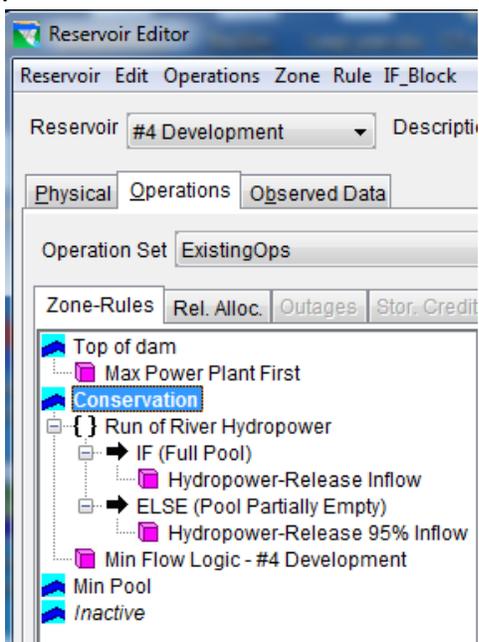


Figure 7: Reservoir Editor: Operations Tab – Existing Ops OpSet – Zones and Rules

<sup>33</sup> TransCanada. Deerfield River Operational Constraints. 2012.

## C. Rule Descriptions

### 1. Max Power Plant First

Figure 8 shows the content of “Max Power Plant First” rule. This rule forces the inflow to pass through the power plant first until it reaches the maximum plant capacity.

The screenshot shows the 'Max Power Plant First' rule configuration in the Reservoir Editor. The 'Function of' is set to '#4 Development-Pool Net Inflow, Current Value'. The 'Limit Type' is 'Maximum' and 'Interp.' is 'Linear'. The table below shows the flow and release values:

Flow (cfs)	Release (cfs)
-1000.0	0.0
0.0	0.0
1204.8	1204.8
123456.0	1204.8

The graph on the right shows Release (cfs) on the y-axis (0 to 1,200) and Flow (cfs) on the x-axis (0 to 120,000). The release is 0 for flow up to 1204.8, then increases linearly to 1204.8 at a flow of 123456.0, and remains constant at 1204.8 for higher flows.

Options on the right include:

- Period Average Limit
- Hour of Day Multiplier
- Day of Week Multiplier
- Rising/Falling Condition
- Seasonal Variation

Figure 8: Reservoir Editor: Operations Tab – Existing Ops OpSet – Max Power Plant First

## 2. Run of River Hydropower

Figure 8 shows the content of “Run of River Hydropower” rule. This rule release total inflow through power plant when pool elevation is higher than conservation elevation and 95% of inflow when pool elevation is less than conservation zone as per the run-of-river modeling strategy.

The image displays two screenshots of a software interface for configuring a hydropower rule. Both screenshots show the 'Operation Set' as 'ExistingOps' and the 'Description' field empty.

**Top Screenshot:** The 'Zone-Rules' pane on the left shows a tree structure under 'Run of River Hydropower'. The 'IF (Full Pool)' rule is selected. The main pane shows 'Operates Release From: #4 Development-Power Plant' and 'IF Conditional: Full Pool'. A table below defines the condition:

Value1	Value2
#4 Development-Pool:Elevation	>= 469.6

**Bottom Screenshot:** The 'Zone-Rules' pane shows 'Hydropower-Release Inflow' selected. The main pane shows 'Operates Release From: #4 Development-Power Plant' and 'Rule Name: ydropower-Release Inflow'. The 'Function of:' is '#4 Development-Pool Net Inflow, Current Value'. The 'Limit Type' is 'Mini...' and 'Interp.' is 'Li...'. A table below defines the release flow:

Flow (cfs)	Release (cfs)
0.0	0.0
10000.0	10000.0

To the right of the table is a graph showing 'Release (cfs)' on the y-axis (0 to 12,000) and 'Flow (cfs)' on the x-axis (0 to 9,000). The graph shows a linear relationship where release equals flow. Below the graph are several checkboxes for advanced settings: 'Period Average Limit', 'Hour of Day Multiplier', 'Day of Week Multiplier', 'Rising/Falling Condition', and 'Seasonal Variation', each with an 'Edit...' button.

Operation Set: ExistingOps Description: [ ]

Zone-Rules: Rel. Alloc. Outages Stor. Credit Dec. Sched. Projected Elev

Top of dam  
 Max Power Plant First  
 Conservation  
 Run of River Hydropower  
 IF (Full Pool)  
 Hydropower-Release Inflow  
 ELSE (Pool Partially Empty)  
 Hydropower-Release 95% Inflow  
 Min Flow Logic - #4 Development  
 Min Pool  
 Inactive

Operates Release From: #4 Development-Power Plant  
 ELSE Conditional: Pool Partially Empty Description: [ ]

---

Operation Set: ExistingOps Description: [ ]

Zone-Rules: Rel. Alloc. Outages Stor. Credit Dec. Sched. Projected Elev

Top of dam  
 Max Power Plant First  
 Conservation  
 Run of River Hydropower  
 IF (Full Pool)  
 Hydropower-Release Inflow  
 ELSE (Pool Partially Empty)  
 Hydropower-Release 95% Inflow  
 Min Flow Logic - #4 Development  
 Min Pool  
 Inactive

Operates Release From: #4 Development-Power Plant  
 Rule Name: Lower-Release 95% Inflow Description: [ ]  
 Function of: #4 Development-Pool Net Inflow, Current Value Define...  
 Limit Type: Mini... Interp.: Li...  

Flow (cfs)	Release (cfs)
0.0	0.0
10000.0	9500.0

Period Average Limit Edit...  
 Hour of Day Multiplier Edit...  
 Day of Week Multiplier Edit...  
 Rising/Falling Condition Edit...  
 Seasonal Variation Edit...

Figure 8 Reservoir Editor: Operations Tab – Existing Ops OpSet – Run of River hydropower

### 3. Min Flow Logic#4 Development

This rule represents seasonal minimum flow as represented in Figure 9.

The screenshot shows the 'Operations Tab' for the 'ExistingOps' operation set. The 'Min Flow Logic - #4 Development' rule is selected in the tree view. The main configuration area shows the following details:

- Operates Release From:** #4 Development
- Rule Name:** w Logic - #4 Development
- Description:** Seasonal min rules which are accounting for smolt passage from 01Apr
- Function of:** #4 Development-Pool Net Inflow, Current Value
- Limit Type:** Minimum
- Interp.:** Linear

The central table defines the release values (cfs) for different flow levels across various dates:

Flow (cfs)	Release (cfs)						
	01Jan	01Apr	01Jun	16Jun	15Sep	01Oct	16Nov
0.0	0.0	60.0	60.0	0.0	60.0	60.0	0.0
60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0
100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
125.0	100.0	100.0	125.0	125.0	125.0	100.0	100.0
123456.0	100.0	100.0	125.0	125.0	125.0	100.0	100.0

On the right, a graph plots 'Release (cfs)' against 'Flow (cfs)'. The graph shows a horizontal line at 120 cfs for flow values up to approximately 40,000 cfs, and then a vertical line at 120 cfs for higher flow values. Below the graph are several checkboxes for advanced settings:

- Period Average Limit
- Hour of Day Multiplier
- Day of Week Multiplier
- Rising/Falling Condition
- Seasonal Variation

Figure 9: Reservoir Editor: Operations Tab – Existing Ops OpSet – Min Flow Logic #4 Development

## Deerfield No. 5 Development

### I. Overview

Deerfield No. 5 Development is located in the town of Monroe, MA on the Deerfield River. It is owned and operated by TransCanada Hydro Northeast Inc. for hydropower generation on a run-of-river basis.

Figure 1 shows the location of Deerfield No. 5 dam as it is represented in the HEC-ResSim model .Figure 2 shows the photo of Deerfield No.5 dam.

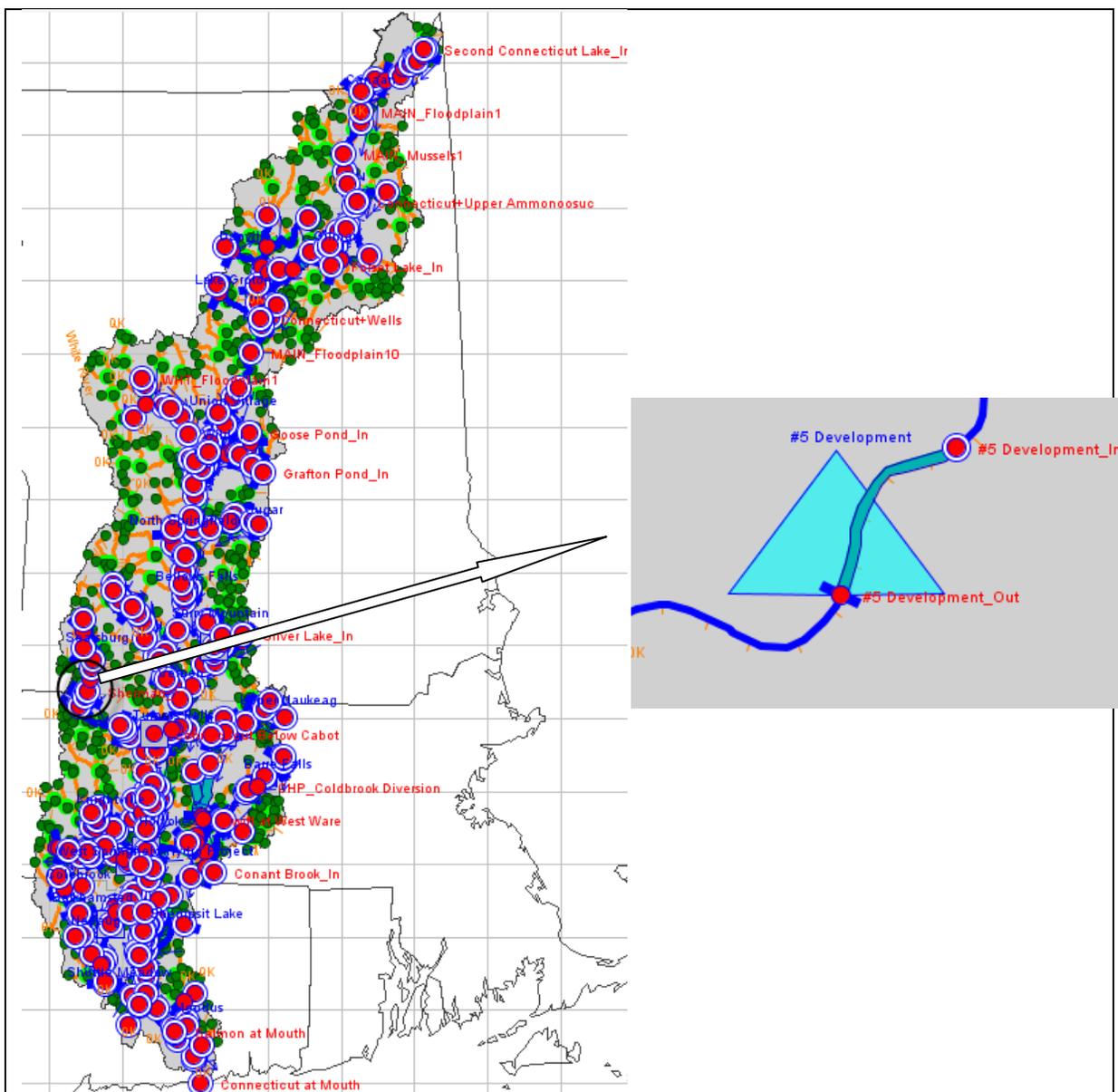


Figure 1: HEC-ResSim Map Display Showing Location of Deerfield No.5



Figure 2: Photo of Deerfield No.5 Development

## II. Physical Characteristics

The physical characteristics of the reservoir are separated between the Pool and the Dam in the HEC-ResSim model. The elevation-storage-area defines the pool as shown in Figure 3<sup>34</sup>. The dam consists of five types of outlets: (1) controlled sluice gate, (2) controlled spillway, (3) controlled Flap gate, (4) controlled flood gate, and (5) power plant as shown in Figure 4.

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<sup>34</sup> Data provided by TransCanada

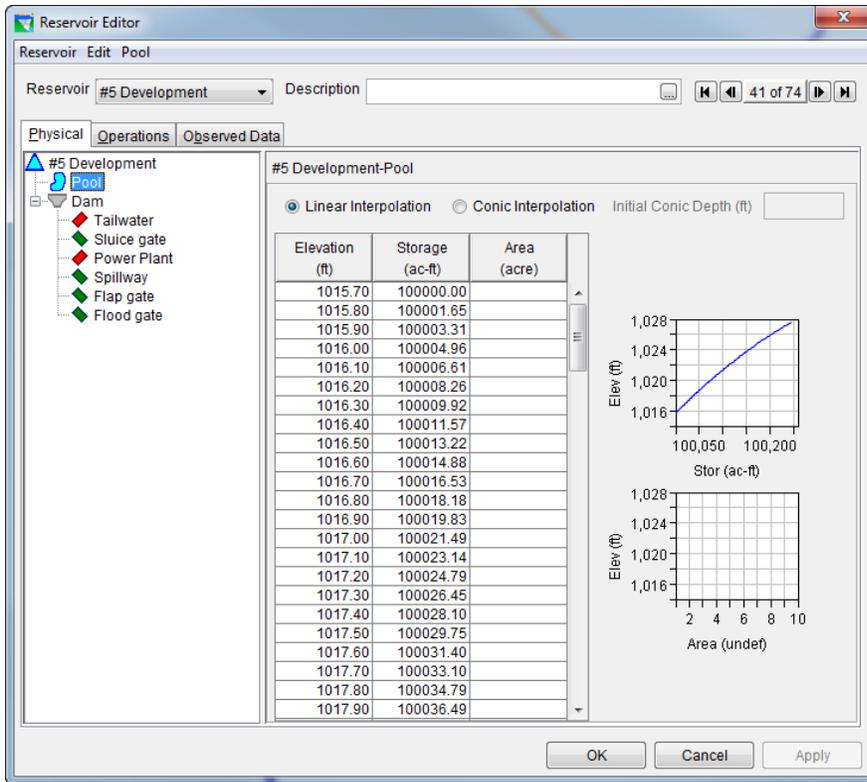


Figure 3: Reservoir Editor: Physical Tab -- Pool

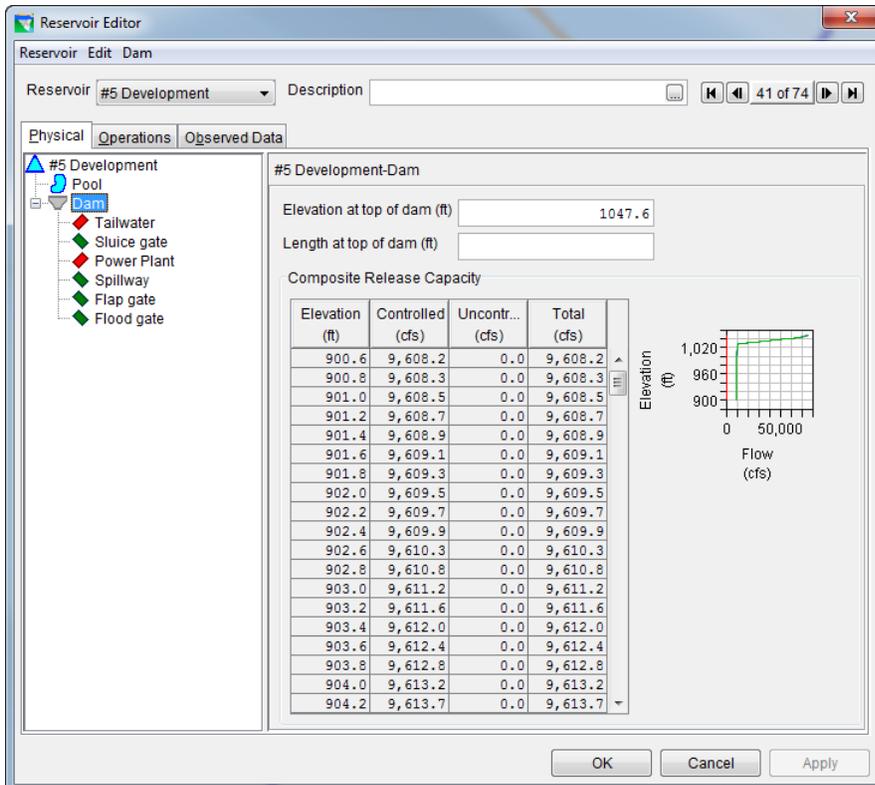


Figure 4: Reservoir Editor: Physical Tab -- Dam



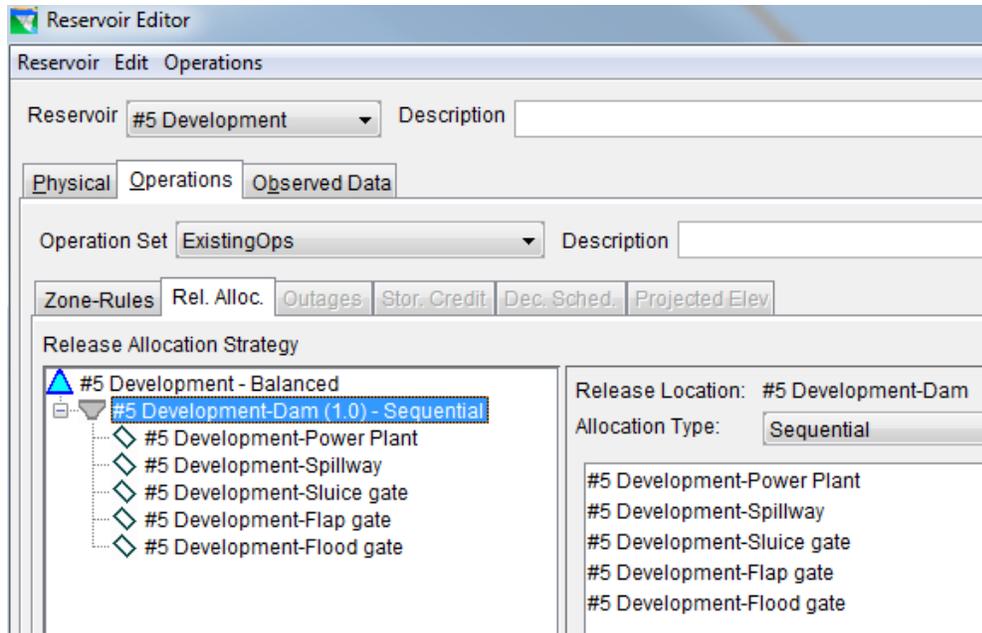


Figure 6: Reservoir Editor: Operations Tab – Existing Ops OpSet – Release Allocation

## B. Rule Illustrations

Figure 7 shows a set of operational rules specified for each zone that reflects the operation set named Existing Ops<sup>35</sup>.

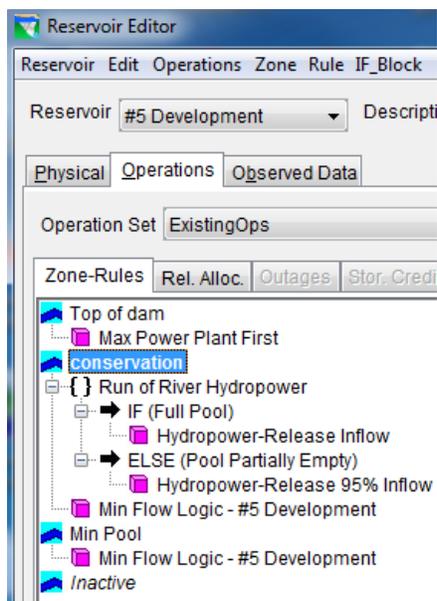


Figure 7: Reservoir Editor: Operations Tab – Existing Ops OpSet – Zones and Rules

<sup>35</sup> TransCanada. Deerfield River Operational Constraints. 2012.

## C. Rule Descriptions

### 1. Max Power Plant First

Figure 8 shows the content of “Max Power Plant First” rule. This rule forces the inflow to pass through the power plant first until it reaches the maximum plant capacity.

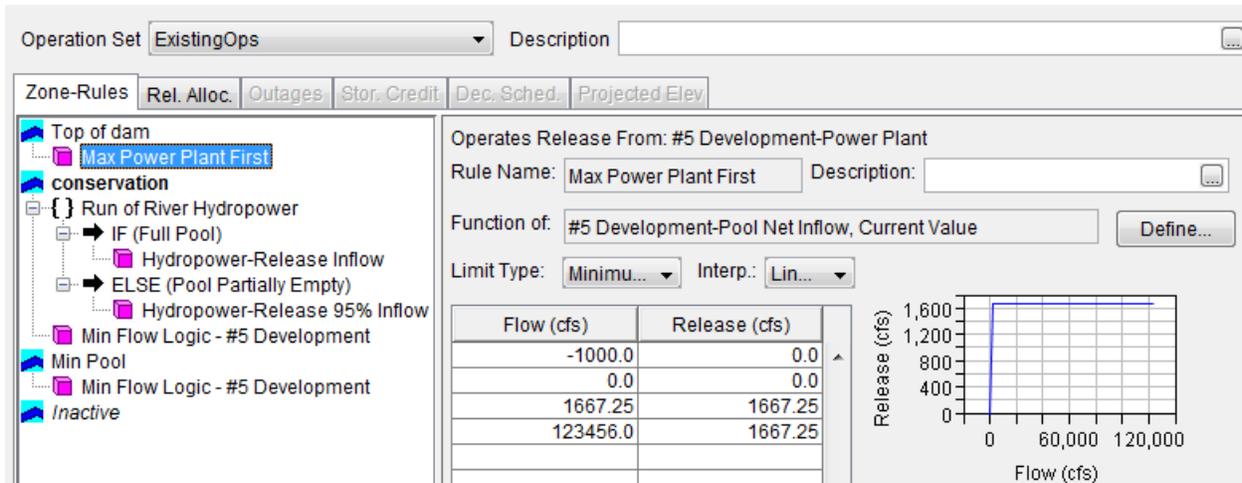
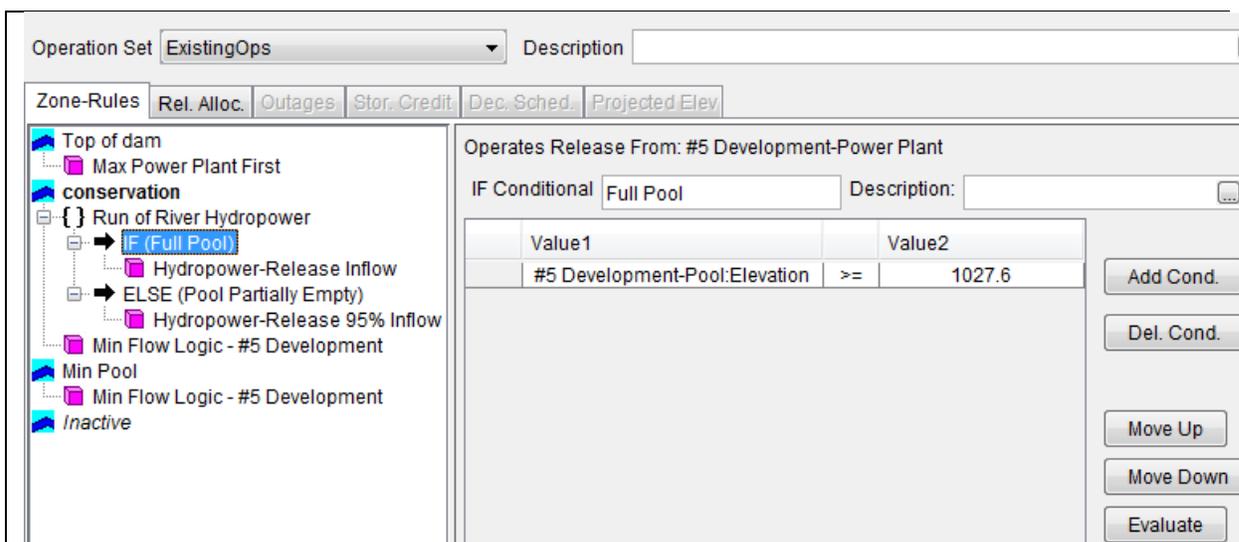


Figure 8: Reservoir Editor: Operations Tab – Existing Ops OpSet – Max Power Plant First

### 2. Run of River Hydropower

Figure 9 shows the content of “Run of River Hydropower” rule. This rule release total inflow through power plant when pool elevation is higher than conservation elevation and 95% of inflow when pool elevation is less than conservation zone as per the run-of-river modeling strategy.



Operation Set ExistingOps Description

Zone-Rules Rel. Alloc. Outages Stor. Credit Dec. Sched. Projected Elev

Operates Release From: #5 Development-Power Plant

Rule Name: ydropower-Release Inflow Description:

Function of: #5 Development-Pool Net Inflow, Current Value Define...

Limit Type: Minimum... Interp.: Lin...

Flow (cfs)	Release (cfs)
0.0	0.0
10000.0	10000.0

Release (cfs)

Flow (cfs)

Period Average Limit Edit...

Hour of Day Multiplier Edit...

Day of Week Multiplier Edit...

Rising/Falling Condition Edit...

Seasonal Variation Edit...

Zone-Rules Rel. Alloc. Outages Stor. Credit Dec. Sched. Projected Elev

Operates Release From: #5 Development-Power Plant

ELSE Conditional Pool Partially Empty Description:

Top of dam

- Max Power Plant First
- conservation
  - Run of River Hydropower
    - IF (Full Pool)
      - Hydropower-Release Inflow
      - ELSE (Pool Partially Empty)
      - Hydropower-Release 95% Inflow
    - Min Flow Logic - #5 Development
  - Min Pool
    - Min Flow Logic - #5 Development
  - Inactive

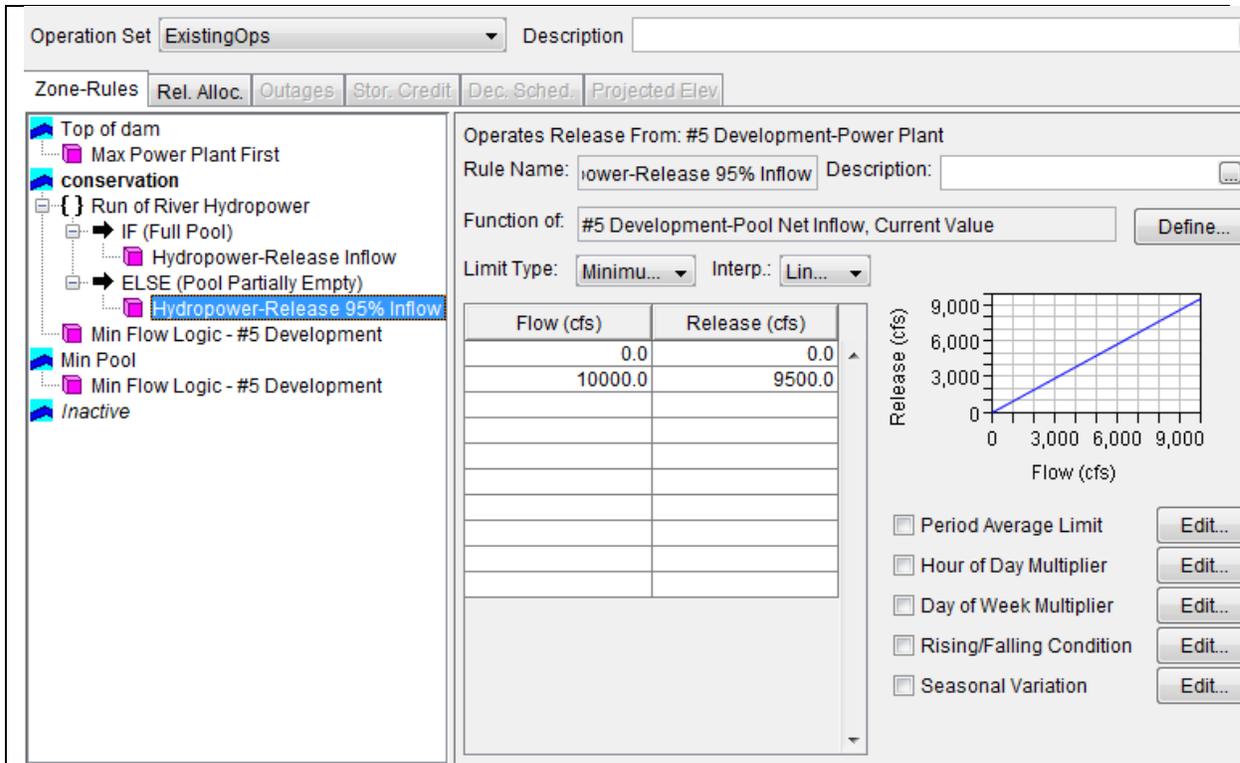


Figure 9: Reservoir Editor: Operations Tab – Existing Ops OpSet – Run of River hydropower

### 3. Min Flow Logic #5 Development

This rule represents a minimum release based on inflow as represented in Figure 10.

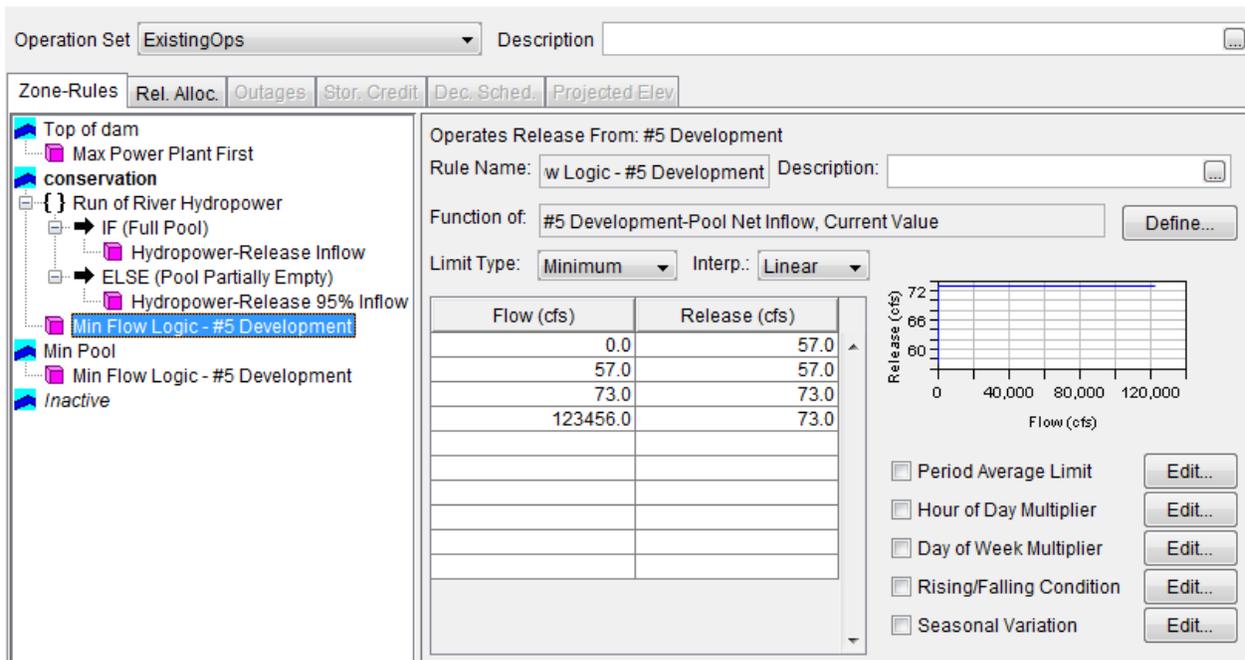


Figure 10: Reservoir Editor: Operations Tab – Existing Ops OpSet – Min Flow Logic #5 Development

## First Connecticut Lake

### I. Overview

First Connecticut Lake dam is located 8 miles upstream of Pittsburg, NH on the mainstem Connecticut River. It is owned and operated by TransCanada Hydro Northeast Inc. as a storage reservoir to make releases to its downstream hydro facilities.

Figure 1 shows the location of Second Connecticut Dam as it is represented in the HEC-ResSim model, and Figure 2 shows a photo from Second Connecticut Dam.

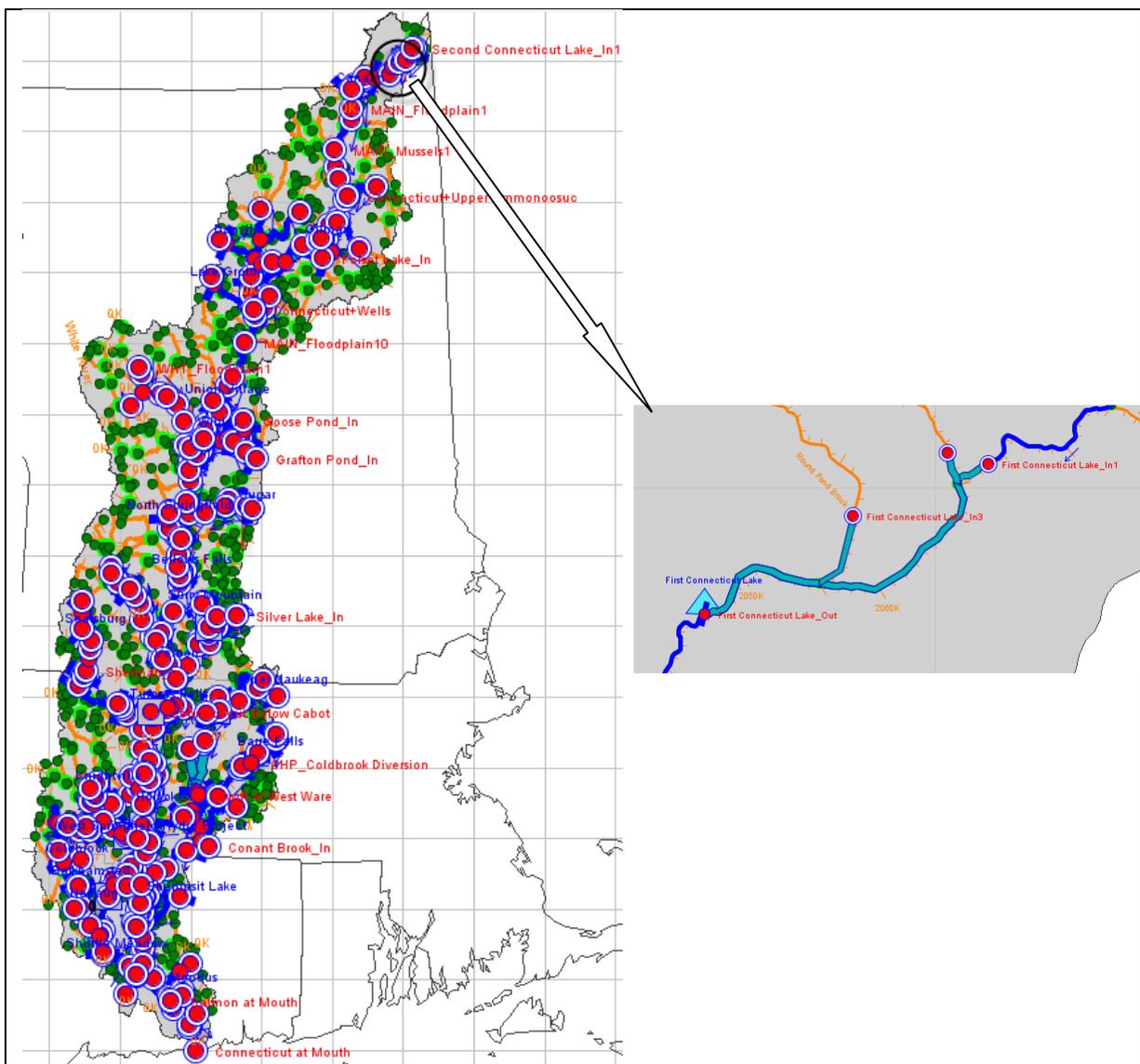
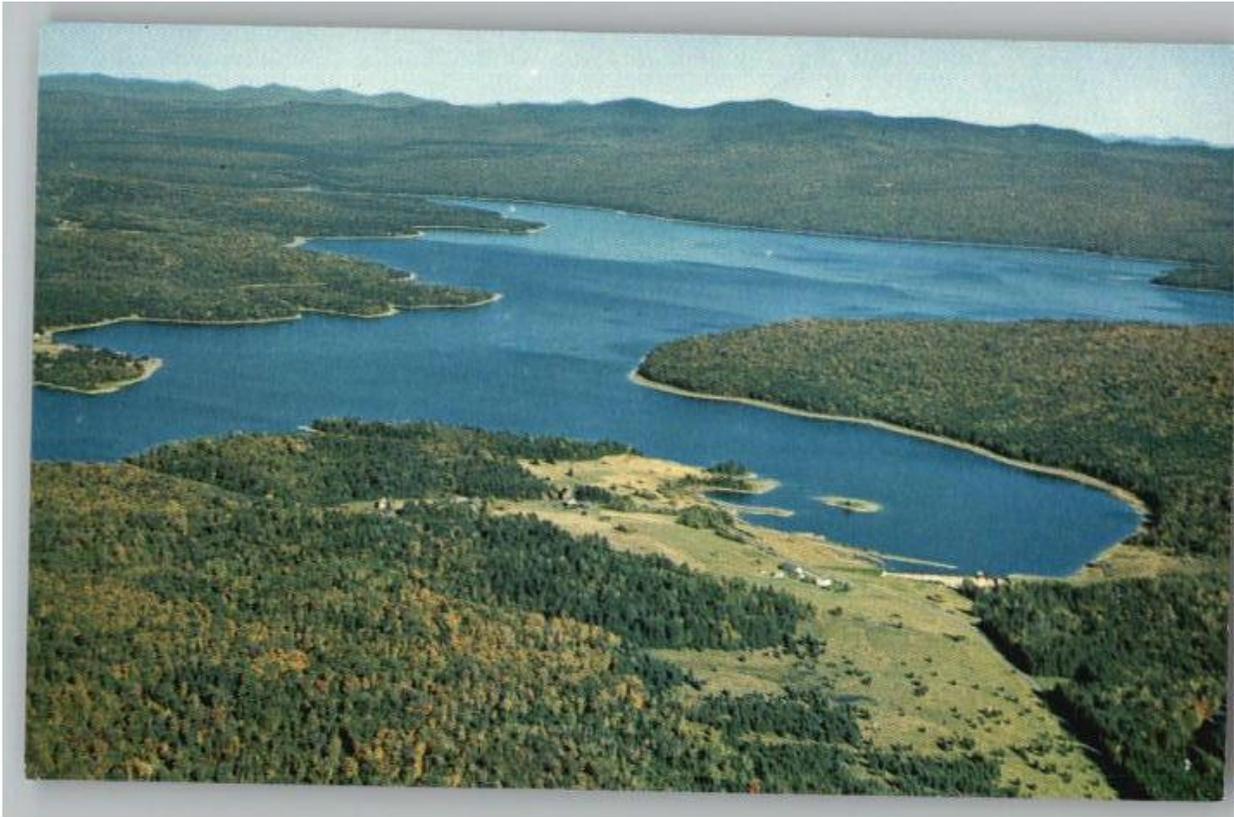


Figure 1: HEC-ResSim Map Display Showing Location of First Connecticut Dam



**Figure 2: Photo of First Connecticut Lake**

## **II. Physical Characteristics**

The physical characteristics of the reservoir are separated between the Pool and the Dam in the HEC-ResSim model. The elevation-storage-area defines the pool as shown in Figure 3<sup>36</sup>. The dam consists of four types of outlets: (1) controlled outlet, (2) uncontrolled spillway, (3) controlled Log way, and (4) controlled Fish Pipe as shown in Figure 4.

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<sup>36</sup> Data provided by TransCanada

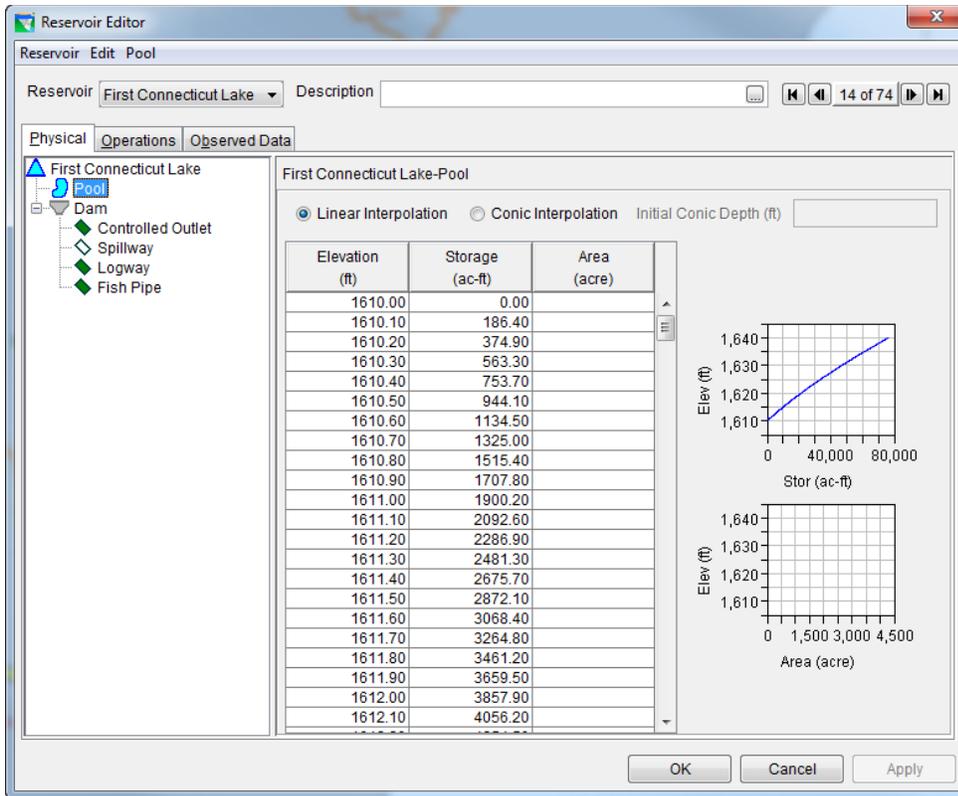


Figure 3: Reservoir Editor: Physical Tab -- Pool

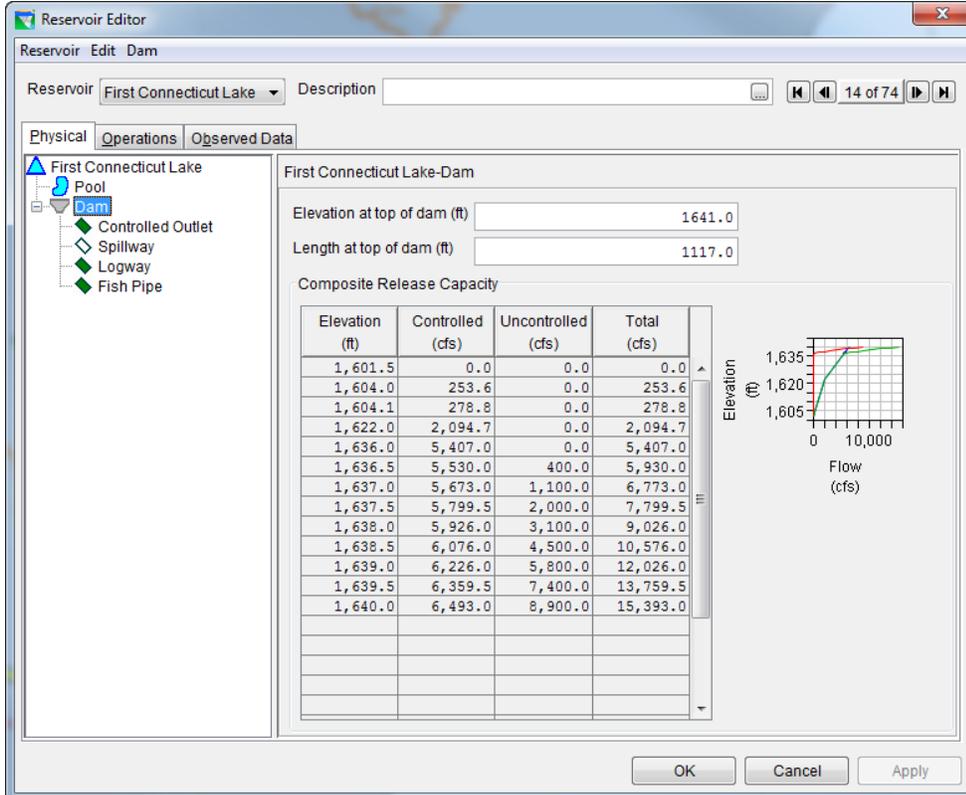


Figure 4: Reservoir Editor: Physical Tab -- Dam

### III. Operations

#### A. Operation Set

Zones are used to define the operational storage in the reservoir to determine the reservoir release through analysis of the rules contained within each zone. Figure 5 shows the definition of First Connecticut Dam’s “Existing Ops” operational zones, which consist of zones of Top of Dam (1641 ft), Below Top of Dam (1640 ft), Conservation (1617.262-1637.493 ft), and Inactive zone (1600 ft). The Conservation Pool Elevation curve was created from 10 years of weekly average pool elevation<sup>1</sup>.

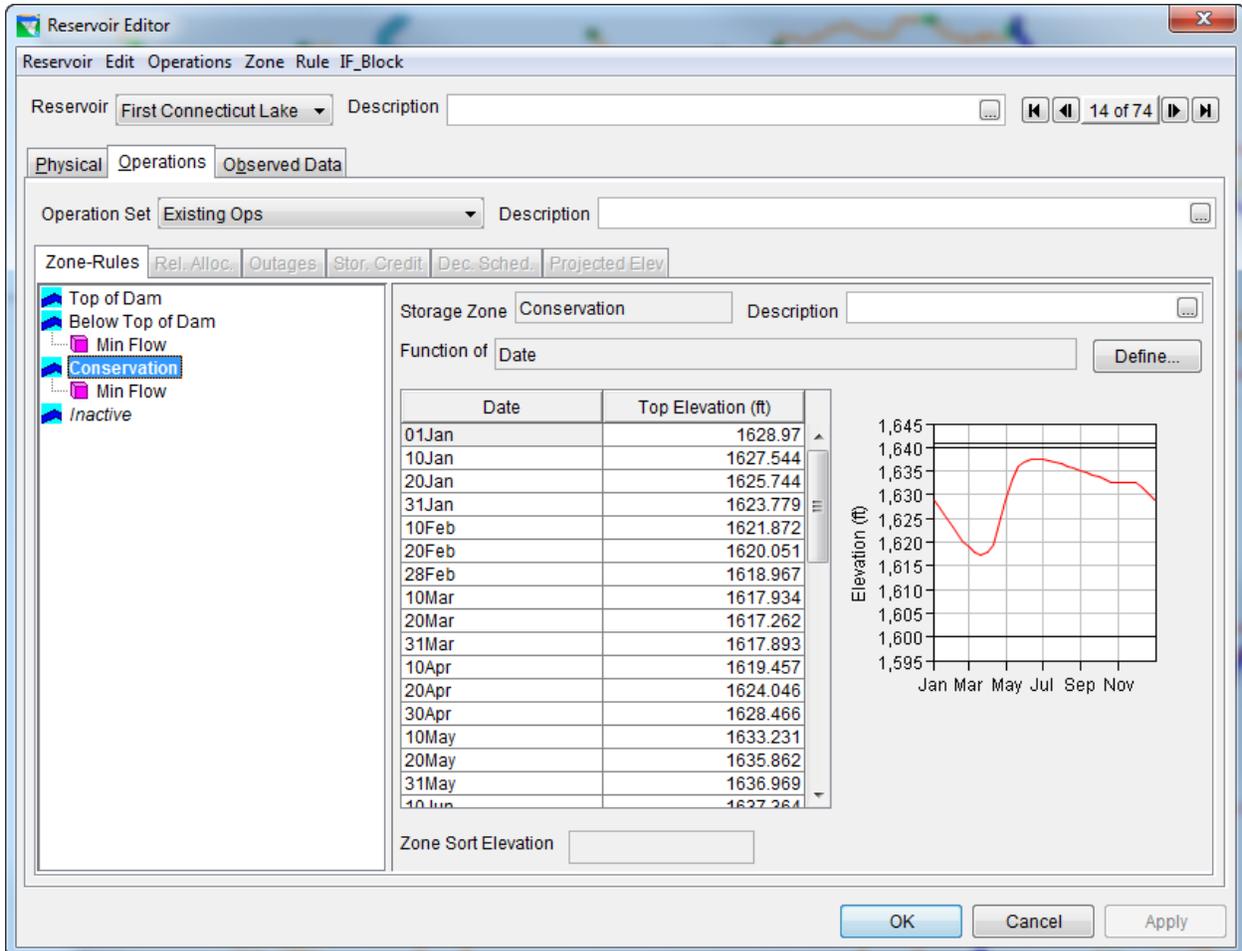


Figure 5: Reservoir Editor: Operations Tab –Existing Ops OpSet – Guide Curve

## B. Rule Illustrations

Figure 6 shows a set of operational rules specified for each zone that reflects the operation set named Existing Ops<sup>37</sup>.

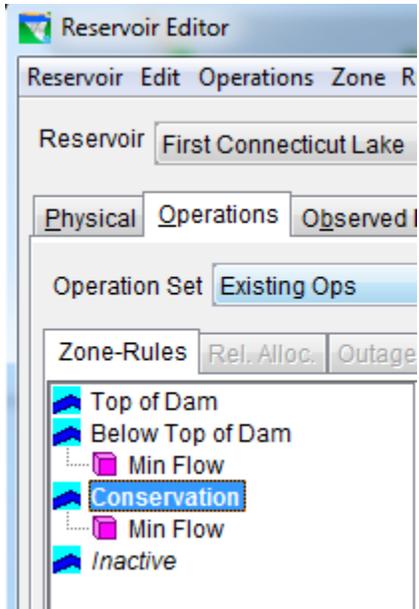


Figure 6: Reservoir Editor: Operations Tab – Existing Ops OpSet – Zones and Rules

<sup>37</sup> TransCanada. Connecticut River Operational Constraints. 2012.

## C. Rule Descriptions

### 1. *Min Flow*

Figure 7 shows the content of “Min Flow” rule. This rule represents the minimum release from dam as a function of date.

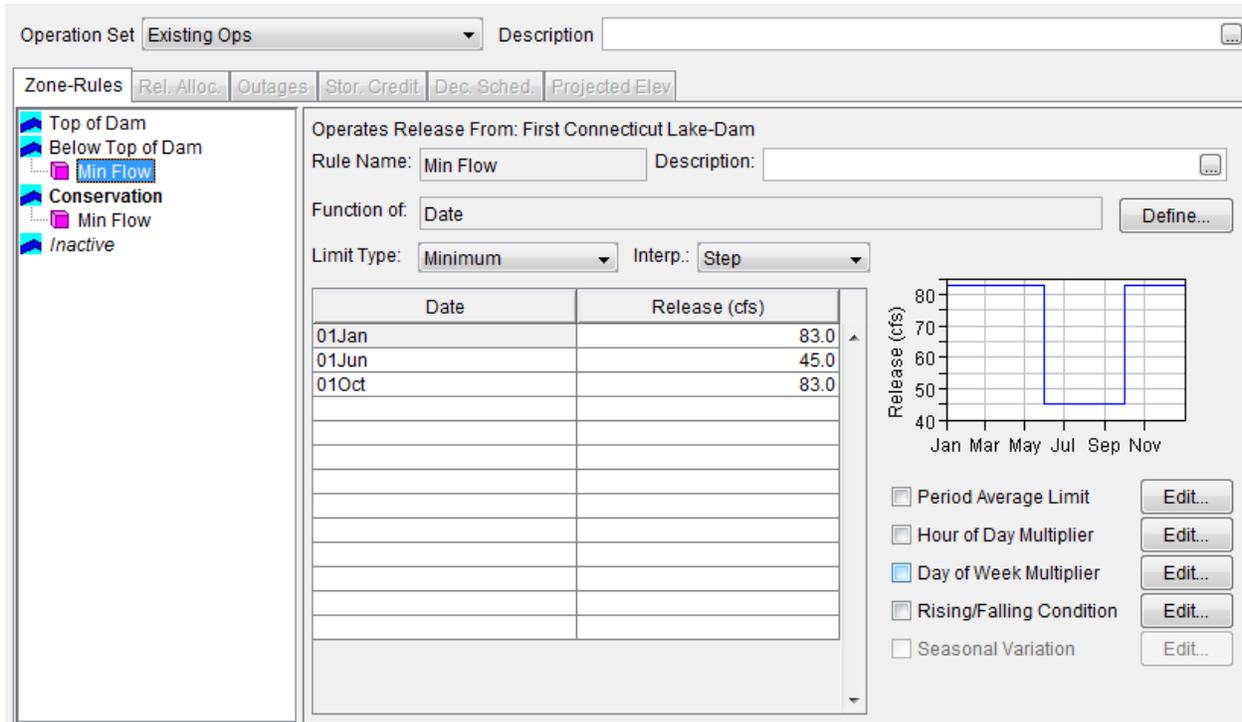


Figure 7: Reservoir Editor: Operations Tab – Existing Ops OpSet – Min Flow

# Forest Lake

## I. Overview

Forest Lake is a dam located in Whitefield, NH on the Johns River. It is owned and operated by the New Hampshire Water Division and is primarily used for water supply and recreation.

Figure 1 shows the location of Forest Lake Dam as it is represented in the HEC-ResSim model. Figure 2 shows a photo of Forest Lake reservoir.

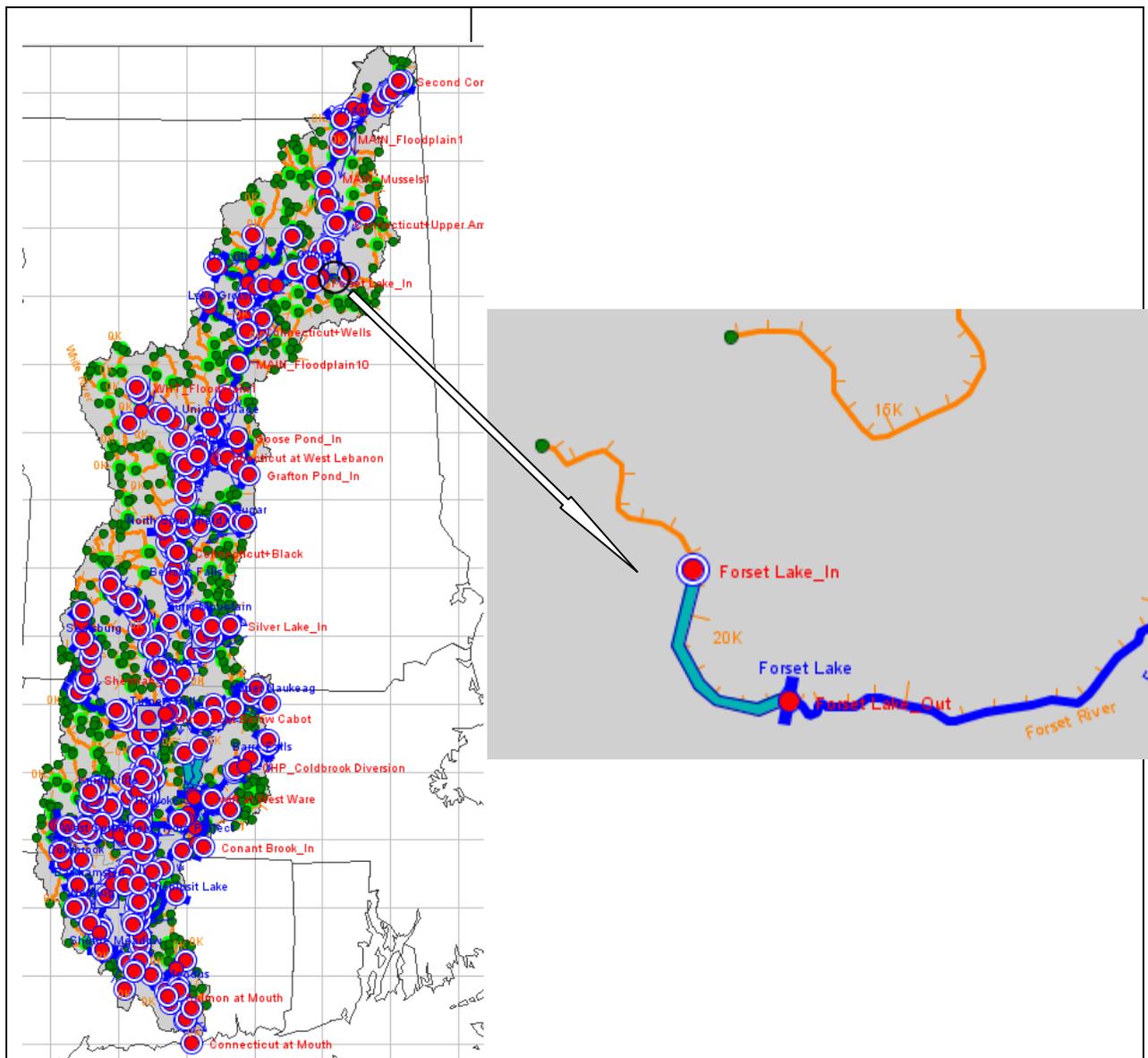


Figure 1: HEC-ResSim Map Display Showing Location of Forest Lake Dam



**Figure 2: Photo of Forest Lake reservoir.**

## **II. Physical Characteristics**

The physical characteristics of the reservoir are separated between the Pool and the Dam in the HEC-ResSim model. The elevation-storage-area defines the pool as shown in Figure 3<sup>38</sup>. The dam consists of two types of outlets: (1) an uncontrolled concrete spillway, and (2) an uncontrolled stoplog bay as shown in Figure 4.

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<sup>38</sup> National Dam Safety Program. Forest Lake Dam Operation & Maintenance Plan. 2007.

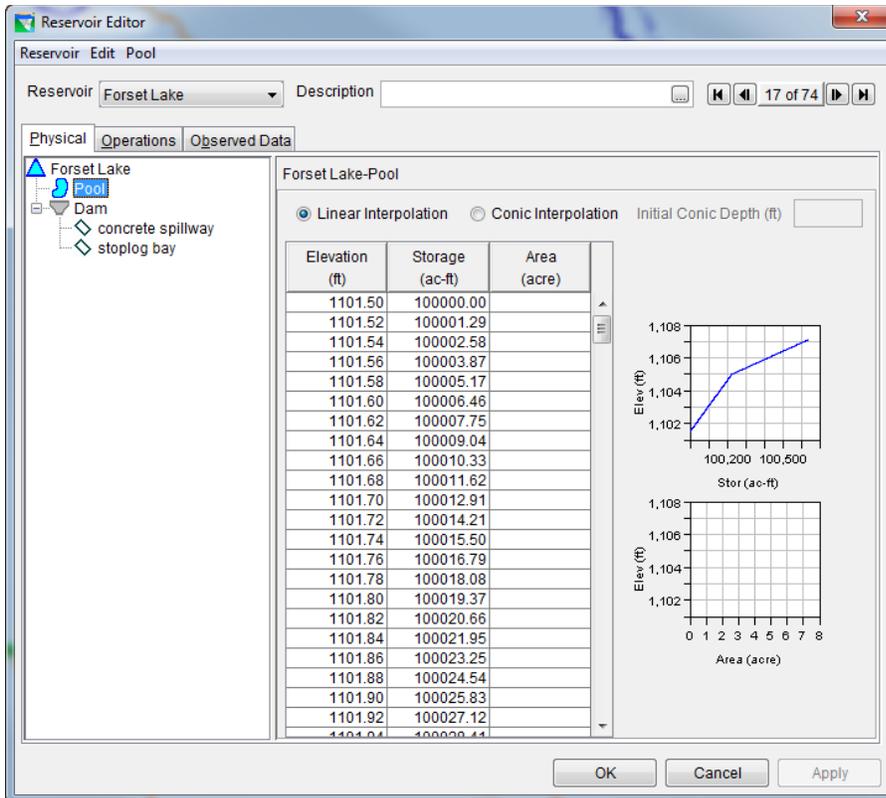


Figure 3: Reservoir Editor: Physical Tab -- Pool

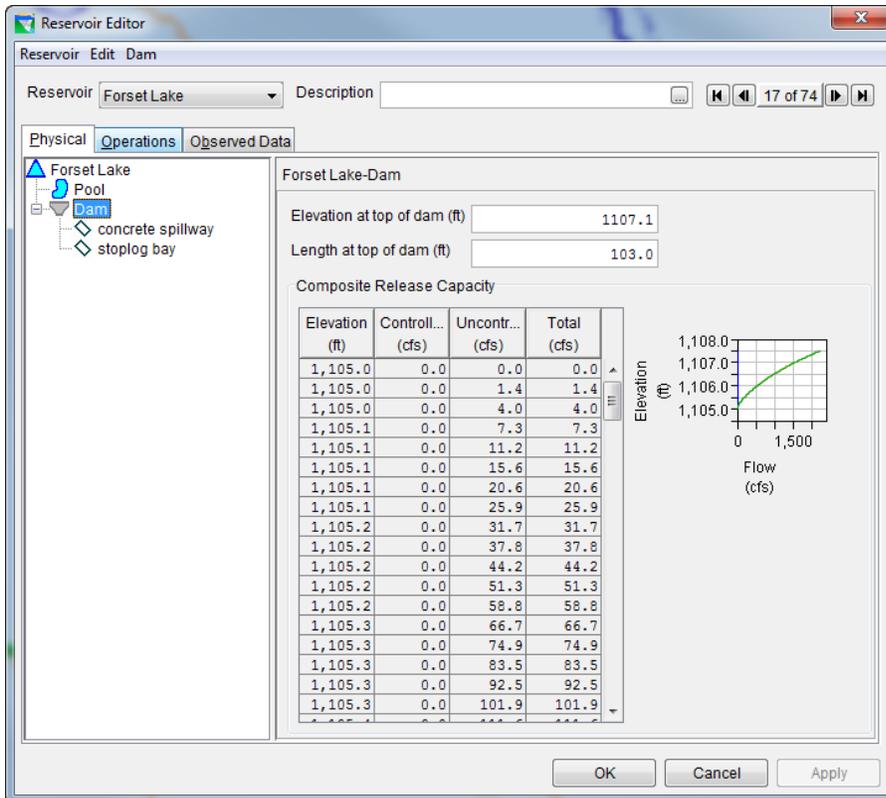


Figure 4: Reservoir Editor: Physical Tab -- Dam

### III. Operations

#### A. Operation Set

Zones are used to define the operational storage in the reservoir to determine the reservoir release through analysis of the rules contained within each zone. Figure 5 shows the definition of Forest Lake Dam’s “Guide Curve” operational zones, which consist of zones of Top of Dam (1107.1 ft), Conservation (1105 ft), and Inactive zone (1102 ft)<sup>1</sup>.

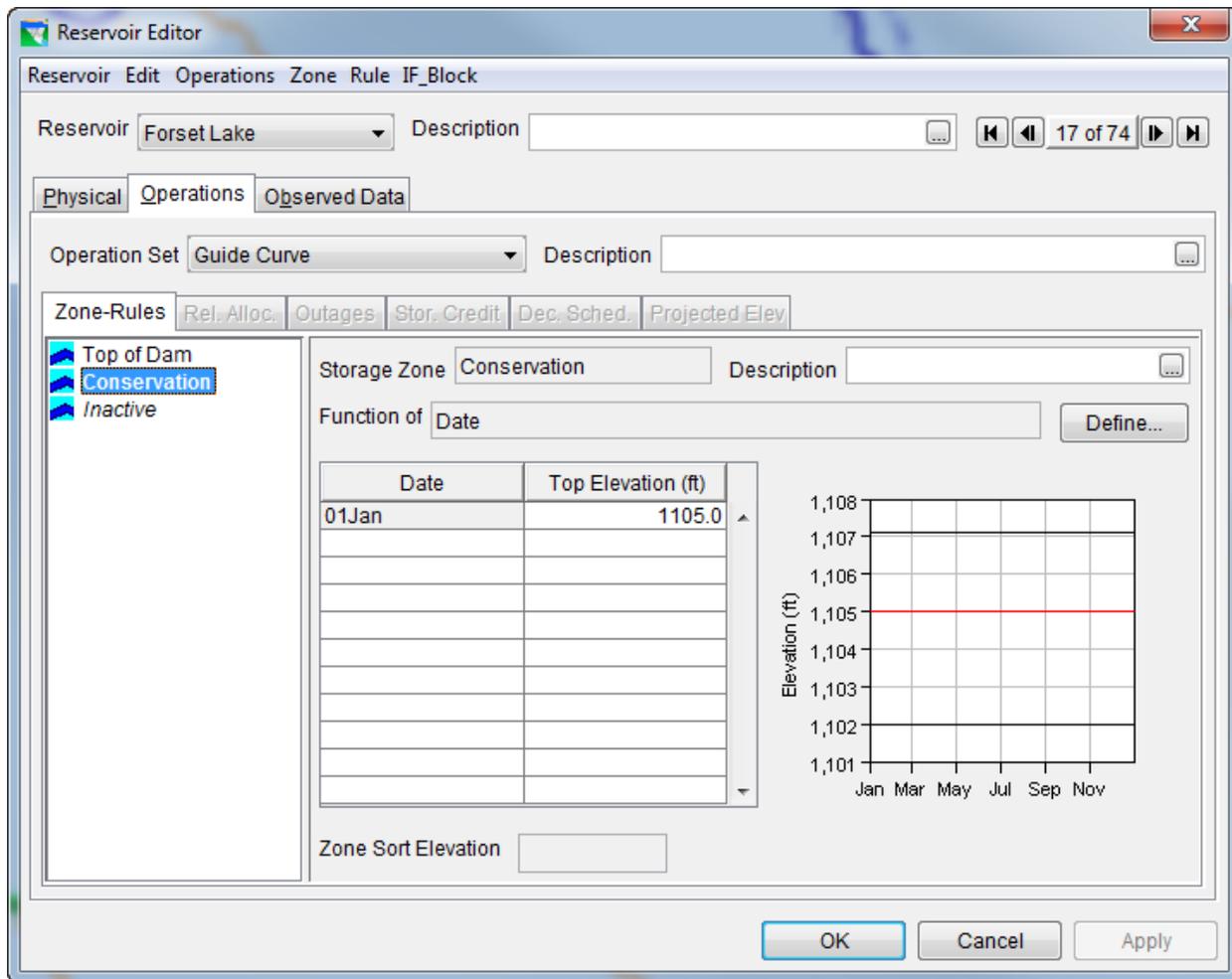


Figure 5 Reservoir Editor: Operations Tab – Guide Curve OpSet

#### B. Rule Illustrations

The operation set for Forest Lake Dam has no rules of operation making it a flow through reservoir. The pool elevation will remain at the top of conservation unless the inflow exceeds the total release capacity.





Figure 2: Photo of Gardner Falls dam

## II. Physical Characteristics

The physical characteristics of the reservoir are separated between the Pool and the Dam in the HEC-ResSim model. The elevation-storage-area defines the pool as shown in Figure 3<sup>39</sup>. The dam consists of two types of outlets: (1) uncontrolled outlet and (3) power plant as shown in Figure 4<sup>1,40</sup>. The capacity of the power plant was made to be the maximum release specified in the NID database so that the dam would modeled completely as run-of-river with some actual physical information.

<sup>39</sup> National Inventory of Dams database (NID)

<sup>40</sup> <http://www.lowimpacthydro.org/lihi-certificate-80-ferc-no.-gardner-falls-project-maine.html>



### III. Operations

#### A. Operation Set

Zones are used to define the operational storage in the reservoir to determine the reservoir release through analysis of the rules contained within each zone. Figure 5 shows the definition of Gardner Falls’s “Guide Curve” operational zones, which consist of Top of Dam (30 ft), Conservation (28.2 ft), and Inactive zone (20 ft)<sup>1</sup>. There was no specified inactive zone so 10 feet below top of dam was arbitrarily chosen.

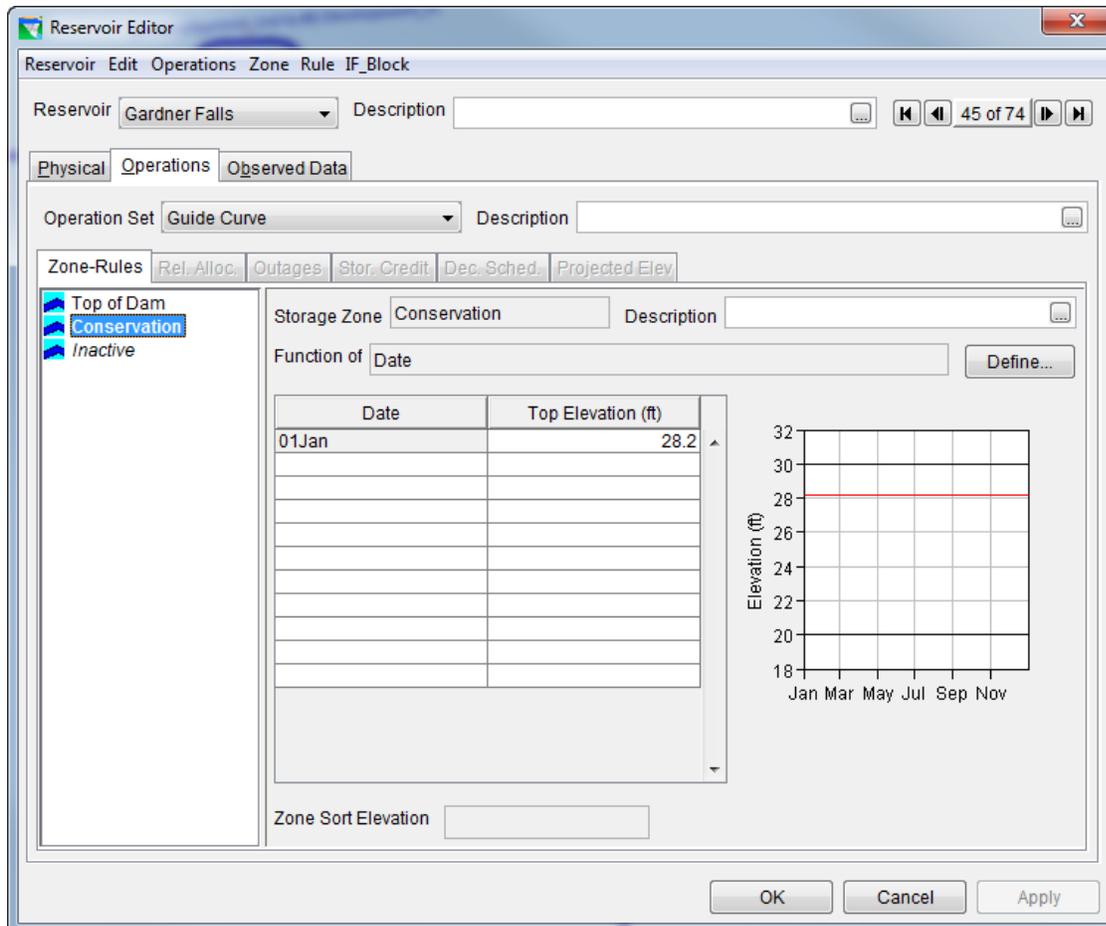


Figure 5: Reservoir Editor: Operations Tab –Guide Curve OpSet – Guide Curve

#### B. Rule Illustrations

The operation set for Gardner Falls has no rules of operation making it a flow through reservoir. The pool elevation will remain at the top of conservation unless the inflow exceeds the total release capacity. This was modeled this way because no real operation information was found.

# Gilman

## I. Overview

Gilman dam is located directly downstream of the town of Dalton, NH on the mainstem Connecticut River. It is owned and operated by Ampersand Gilman Hydro LP for run-of-river hydropower generation.

Figure 1 shows the location of Gilman Dam as it is represented in the HEC-ResSim model, and Figure 2 shows a photo of Gilman Dam.

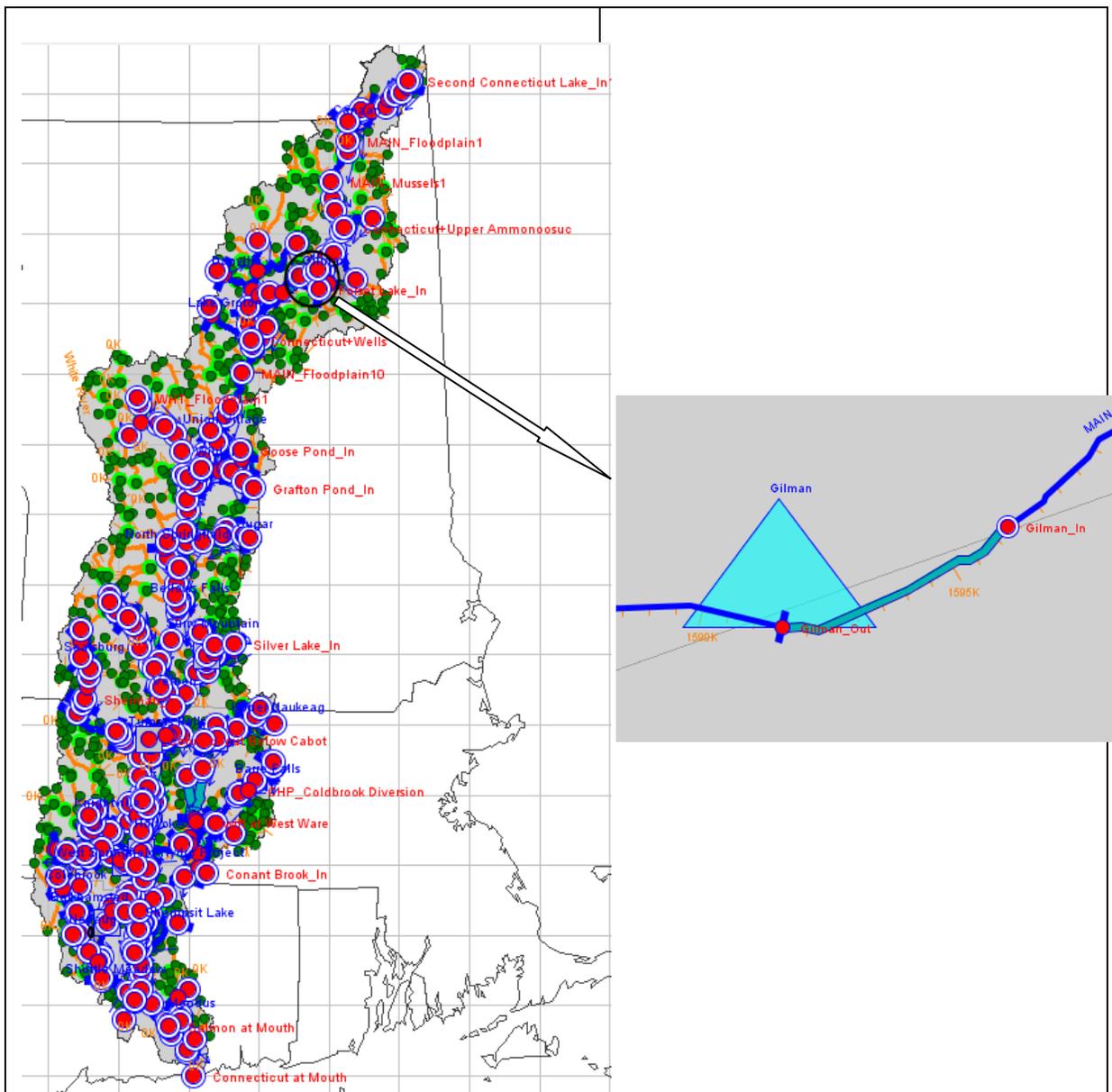


Figure 1: HEC-ResSim Map Display Showing Location of Gilman



Figure 2: Photo of Gilman Dam

## II. Physical Characteristics

The physical characteristics of the reservoir are separated between the Pool and the Dam in the HEC-ResSim model. The elevation-storage-area defines the pool as shown in Figure 3<sup>41</sup>. The dam consists of two types of outlets: (1) controlled outlet, and (2) power plant as shown in Figure 4.

---

<sup>41</sup> NHSDam Data Sheet. Gilman. 2009.





## B. Rule Illustrations

Figure 6 shows a set of operational rules specified for each zone that reflects the operation set named Existing Ops.

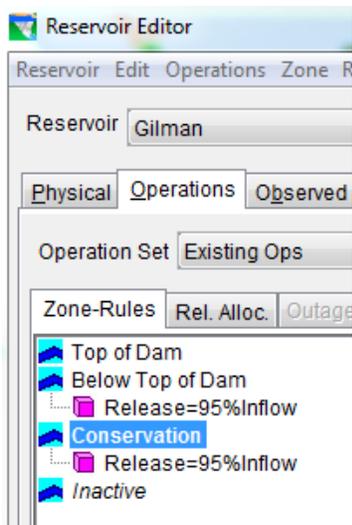


Figure 6: Reservoir Editor: Operations Tab – Existing Ops OpSet – Zones and Rules

## C. Rule Descriptions

### 1. Release=95%Inflow

Figure 7 shows the content of “Release=95%Inflow” rule. This rule release the minimum of 95% of Inflow from dam as per the run-of-river modeling strategy.

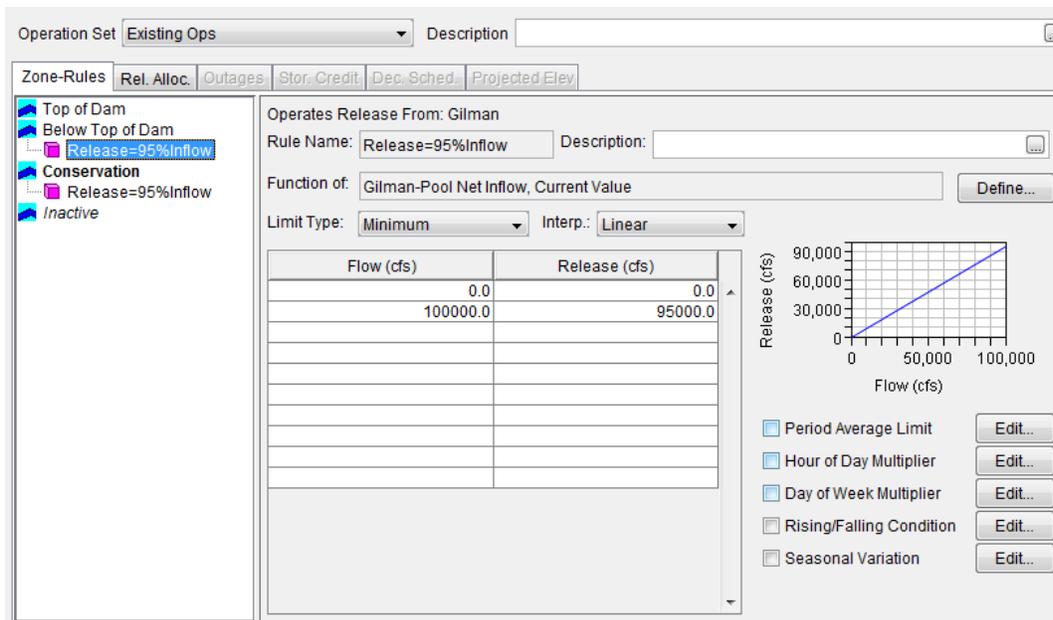


Figure 7 Reservoir Editor: Operations Tab – Existing OpSet – Release=95%Inflow

# Goose Pond

## I. Overview

Goose Pond dam is a dam located in the town of Canaan and feeds into the Mascoma River. It is owned and operated by the State of New Hampshire and is used to store spring runoff to maintain normal flow on the Mascoma River for hydropower generation by other facilities. It is also used for recreation.

Figure 1 shows the location of Goose Pond Dam as it is represented in the HEC-ResSim model. Figure 2 shows a photo of Goose Pond dam.

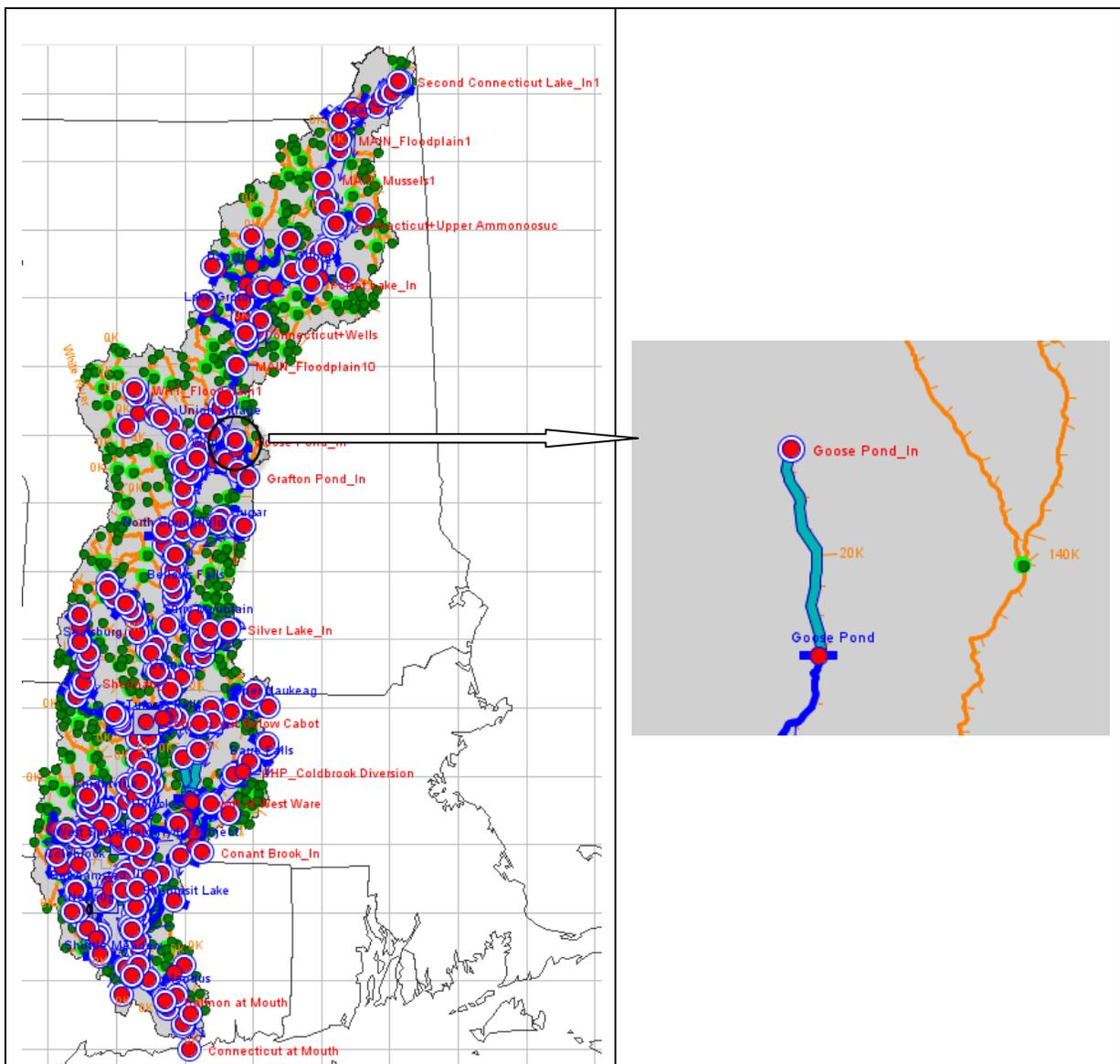


Figure 1: HEC-ResSim Map Display Showing Location of Goose Pond Dam



**Figure 2: Photo of Goose Pond dam.**

## **II. Physical Characteristics**

The physical characteristics of the reservoir are separated between the Pool and the Dam in the HEC-ResSim model. The elevation-storage-area defines the pool as shown in Figure 3<sup>43</sup>. The dam consists of four types of outlets: (1) controlled slide gates, (2) controlled flashboard gate, (3) uncontrolled broad-crested weir, and (4) controlled slide gates as shown in Figure 4.

---

<sup>43</sup> National Dam Safety Program. Goose Pond Dam Operation & Maintenance Plan. 2008.

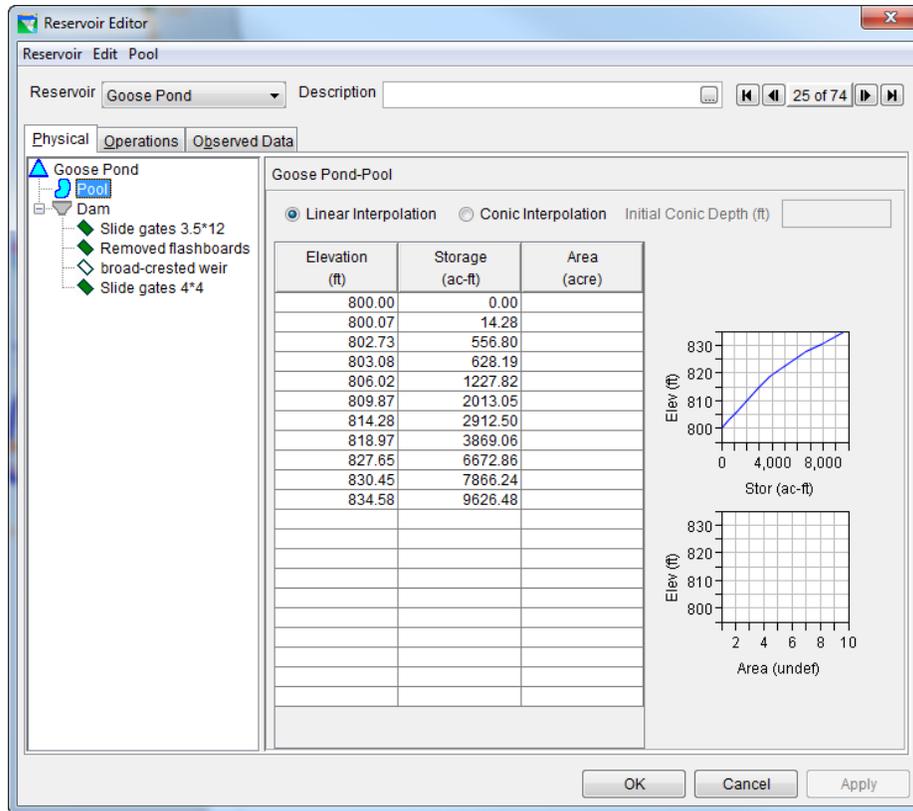


Figure 3: Reservoir Editor: Physical Tab -- Pool

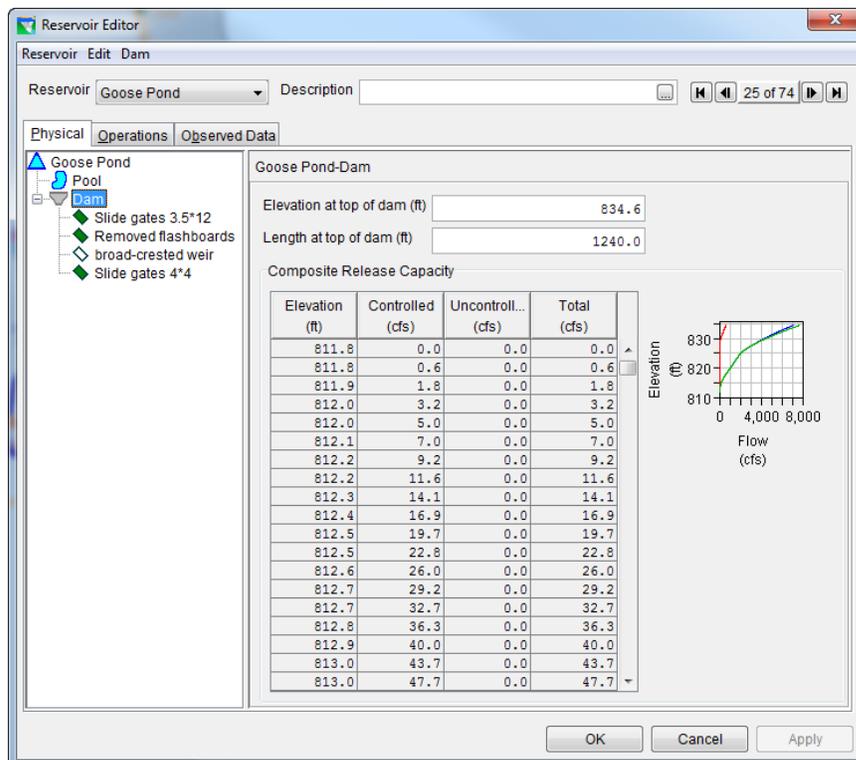


Figure 4: Reservoir Editor: Physical Tab -- Dam

### III. Operations

#### A. Operation Set

Zones are used to define the operational storage in the reservoir to determine the reservoir release through analysis of the rules contained within each zone. Figure 5 shows the definition of Goose Pond Dam’s “ExistingOps” operational zones, which consist of zones of Top of dam (834.6 ft), Flood Control (833 ft), Conservation (824.4-829 ft), and Inactive zone (803.6 ft)<sup>1</sup>.

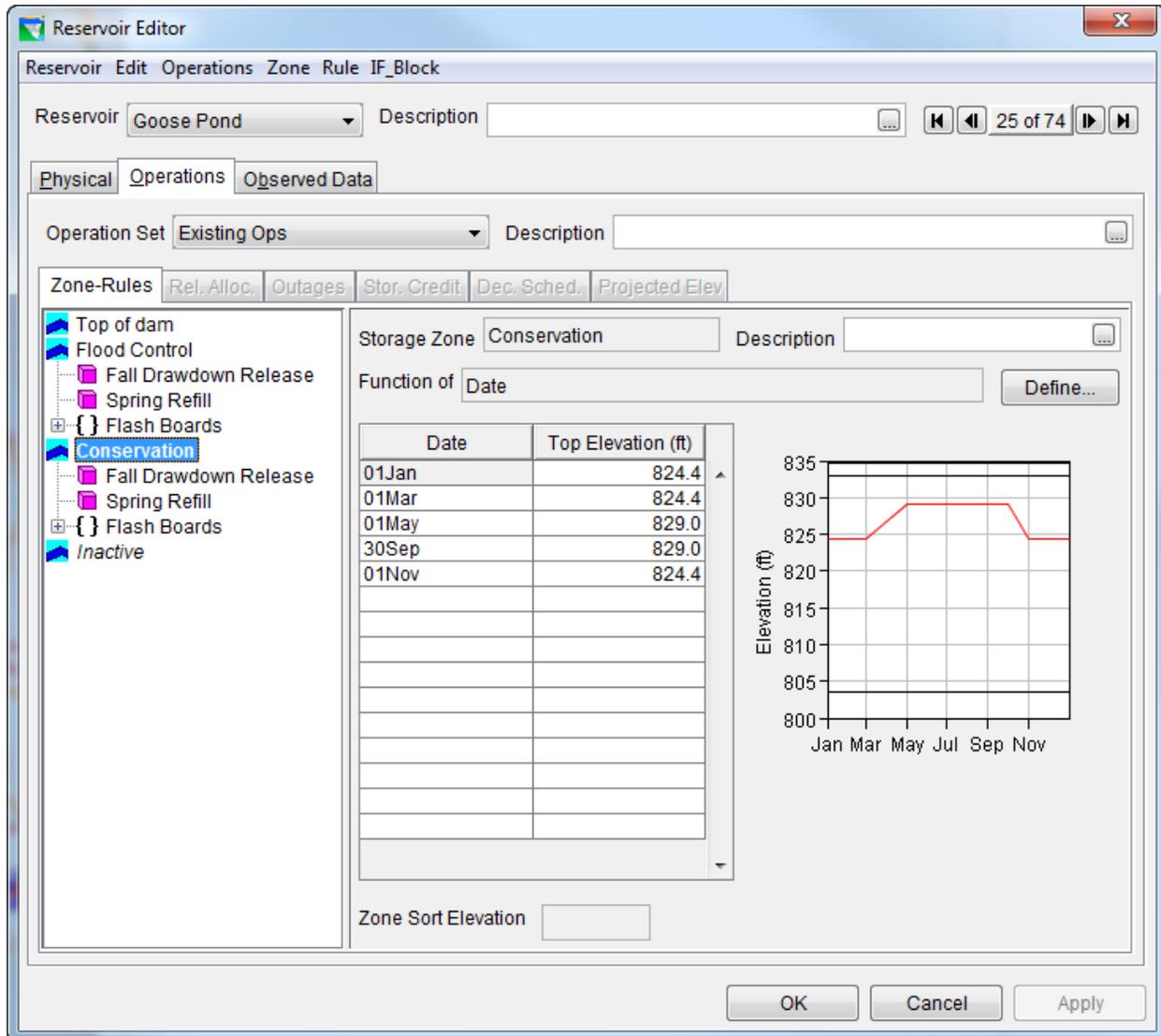


Figure 5: Reservoir Editor: Operations Tab –Existing Ops OpSet – Guide Curve

## B. Rule Illustrations

Figure 6 shows a set of operational rules specified for each zone that reflects the operation set named Existing Ops.

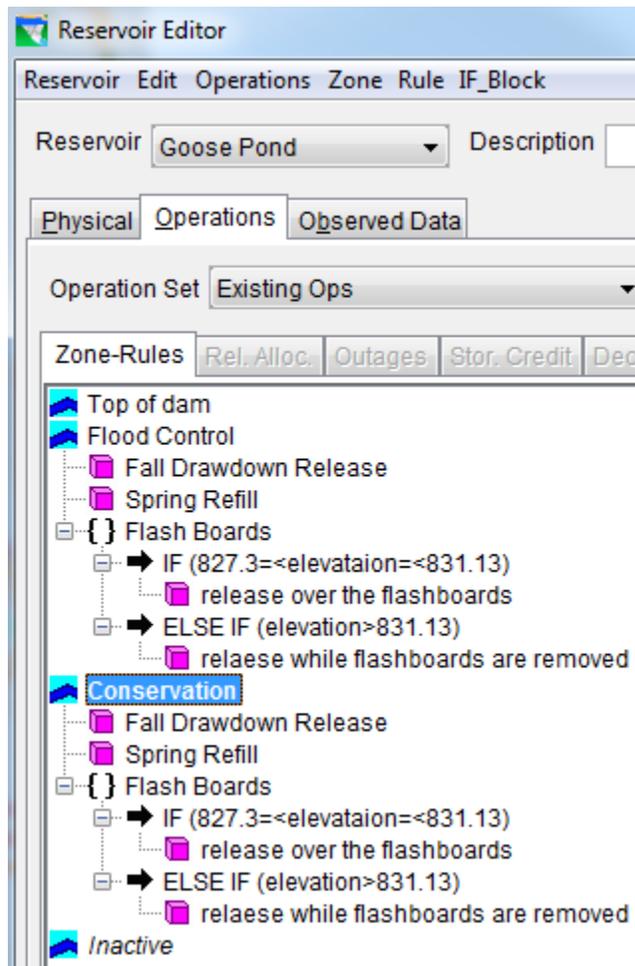


Figure 6: Reservoir Editor: Operations Tab – Existing Ops OpSet – Zones and Rules

## C. Rule Descriptions

### 1. Fall Drawdown Release

Figure 7 shows the content of “Fall Drawdown Release” rule. This rule defines the maximum release from reservoir as a function of pool elevation.

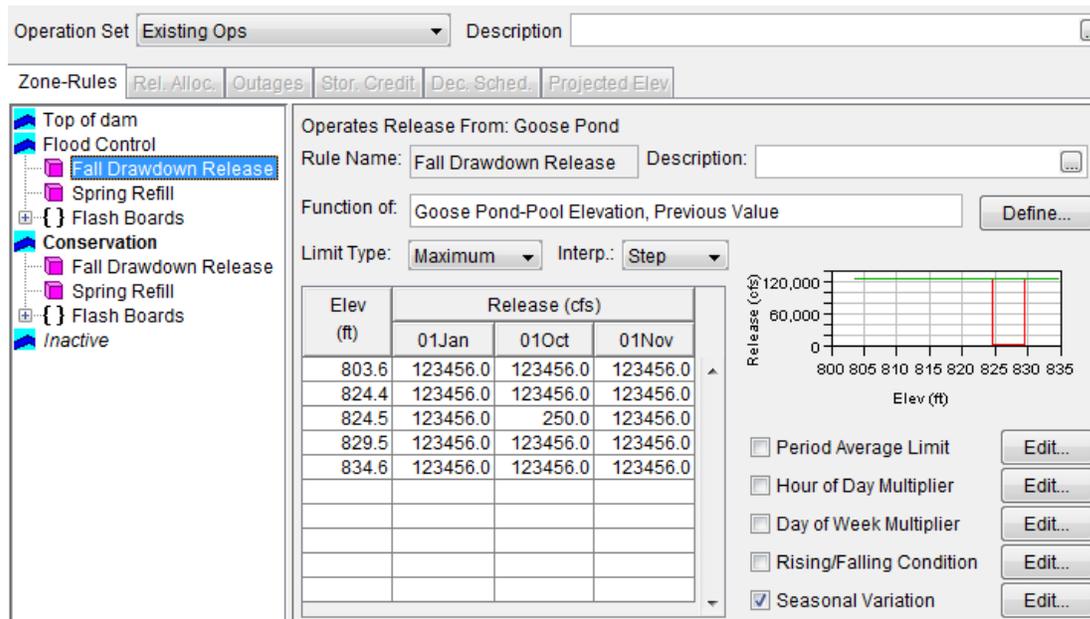


Figure 7: Reservoir Editor: Operations Tab – Existing Ops OpSet – Fall Drawdown Release

### 2. Spring Refill

Figure 8 shows the content of “Spring Refill” rule. This rule represents the seasonal maximum release from reservoir as a function of Inflow.

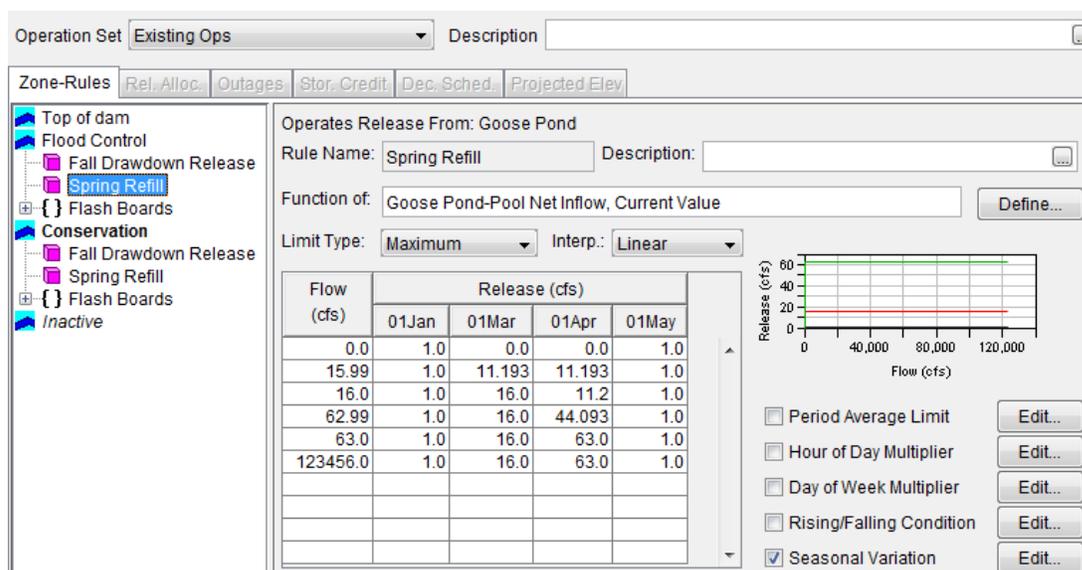


Figure 8: Reservoir Editor: Operations Tab – Existing Ops OpSet – Spring Refill

### 3. Flash Boards

Figure 9 shows the content of “Flash Boards” rule. This rule represents the seasonal maximum flow from reservoir based on Inflow.

The screenshot displays two views of the 'Flash Boards' rule configuration in a software interface. Both views show a tree structure on the left with 'Flash Boards' selected under 'Flood Control'.

**Top Panel:** Shows the rule configuration for 'Flash Boards' operating release from 'Goose Pond'. The rule is defined by two conditions:

Type	Name	Description
IF	827.3=<elevataion=<831.13	
ELSE IF	elevation>831.13	

**Bottom Panel:** Shows a detailed view of the 'Flash Boards' rule, including an 'IF Conditional' section with a table of conditions:

	Value1		Value2
	Goose Pond-Pool:Elevation	>=	827.3
AND	Goose Pond-Pool:Elevation	<=	831.13

An 'Add Cond.' button is visible at the bottom right of the bottom panel.

Operation Set Existing Ops Description

Zone-Rules Rel. Alloc. Outages Stor. Credit Dec. Sched Projected Elev

Top of dam  
 Flood Control  
 Fall Drawdown Release  
 Spring Refill  
 Flash Boards  
 IF (827.3=<elevation=<831.13)  
 release over the flashboards  
 ELSE IF (elevation>831.13)  
 release while flashboards are removed  
 Conservation  
 Fall Drawdown Release  
 Spring Refill  
 Flash Boards  
 Inactive

Operates Release From: Goose Pond  
 Rule Name: ease over the flashboards Description:  
 Function of: Goose Pond-Pool Elevation, Current Value Define...  
 Limit Type: Specified Interp.: Linear

Elev (ft)	Release (cfs)
827.37	2.22
827.44	6.27
827.51	11.52
827.58	17.73
827.65	24.78
827.72	32.57
827.79	41.04
827.86	50.15
827.93	59.83
828.0	70.08
828.07	80.85
828.14	92.11
828.21	103.86
828.28	116.07
828.35	128.72
828.42	141.81
828.49	155.3
828.56	169.2
828.63	183.49

Release (cfs)  
 Elev (ft)  
 Period Average Limit Edit...  
 Hour of Day Multiplier Edit...  
 Day of Week Multiplier Edit...  
 Rising/Falling Condition Edit...  
 Seasonal Variation Edit...

---

Operation Set Existing Ops Description

Zone-Rules Rel. Alloc. Outages Stor. Credit Dec. Sched Projected Elev

Top of dam  
 Flood Control  
 Fall Drawdown Release  
 Spring Refill  
 Flash Boards  
 IF (827.3=<elevation=<831.13)  
 release over the flashboards  
 ELSE IF (elevation>831.13)  
 release while flashboards are removed

Operates Release From: Goose Pond  
 ELSE IF Conditional elevation>831.13 Description:  

Value1	Value2
Goose Pond-Pool:Elevation	> 831.13

 Add Cond.

Operation Set: Existing Ops Description:

Zone-Rules: Rel. Alloc. Outages Stor. Credit Dec. Sched. Projected Elev.

Operates Release From: Goose Pond-Removed flashboards

Rule Name: flashboards are removed Description:

Function of: Goose Pond-Pool Elevation, Current Value Define...

Limit Type: Specified Interp.: Linear

Elev (ft)	Release (cfs)
824.36	1.37
824.43	4.36
824.5	8.31
824.57	13.17
824.64	18.79
824.71	25.08
824.78	31.77
824.85	38.96
824.92	46.62
824.99	54.66
825.06	63.1
825.13	72.21
825.2	82.19
825.27	92.69
825.34	103.57
825.41	114.8
825.48	126.48
825.55	139.0
825.62	152.2

Period Average Limit Edit...  
 Hour of Day Multiplier Edit...  
 Day of Week Multiplier Edit...  
 Rising/Falling Condition Edit...  
 Seasonal Variation Edit...

Figure 9: Reservoir Editor: Operations Tab – Existing Ops OpSet – Flash Boards

## Grafton Pond

### I. Overview

The Grafton Pond Dam lies on a tributary of the Mascoma River close to Enfield Center, NH. The dam is owned and operated by the New Hampshire Water Resources Board. It is primarily used to maintain the level of Grafton Pond for recreation but also has some flood control benefits.

Figure 1 shows the location of Grafton Pond as it is represented in the HEC-ResSim model. Figure 2 shows a photo of Grafton Pond dam.

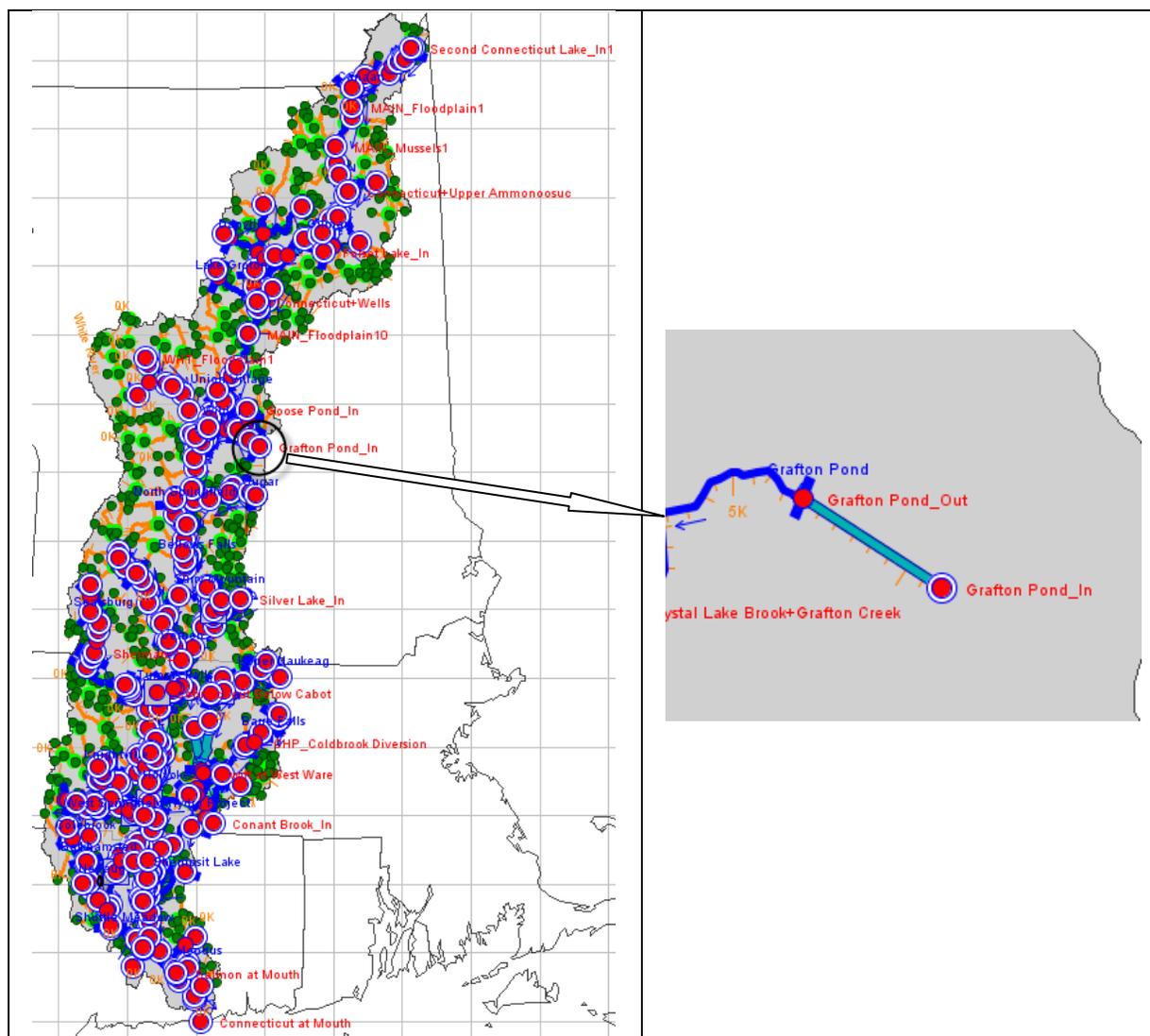


Figure 1: HEC-ResSim Map Display Showing Location of Grafton Pond



Figure 2: Photo of Grafton Pond dam

## II. Physical Characteristics

The physical characteristics of the reservoir are separated between the Pool and the Dam in the HEC-ResSim model. The elevation-storage-area defines the pool as shown in Figure 3<sup>44</sup>. The dam consists of three types of outlets: (1) controlled slide gates, (2) uncontrolled spillway-over TOD, and (3) uncontrolled lower spillway as shown in Figure 4<sup>45</sup>.

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<sup>44</sup> NHDam Data Sheet. Grafton Pond. 2009.

<sup>45</sup> National Dam Safety Program. Grafton Pond Operation and Maintenance Plan. 1978.

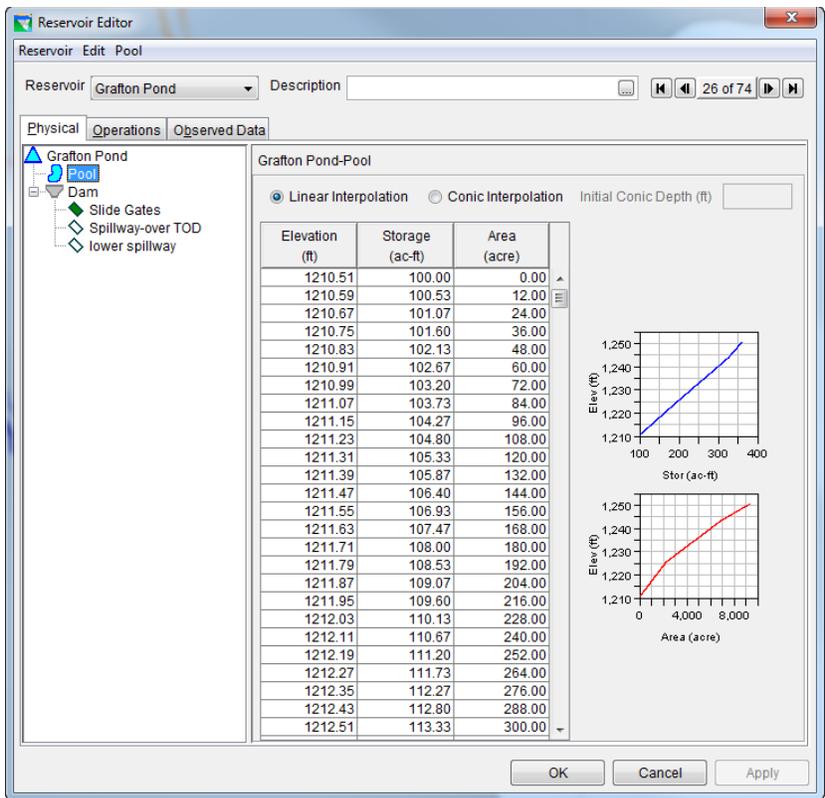


Figure 3: Reservoir Editor: Physical Tab -- Pool

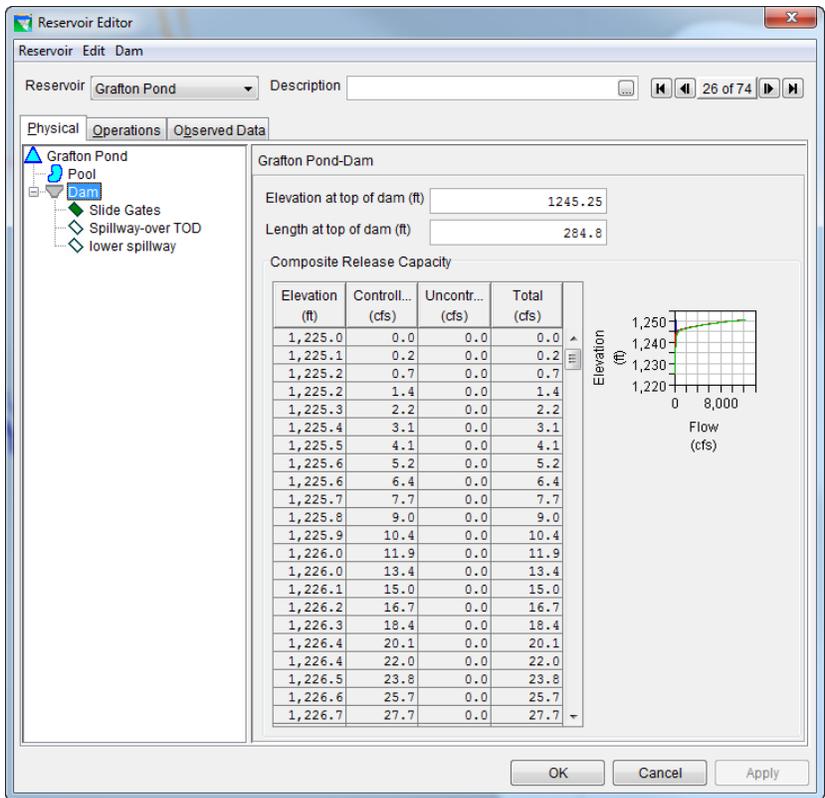


Figure 4: Reservoir Editor: Physical Tab -- Dam

### III. Operations

#### A. Operation Set

Zones are used to define the operational storage in the reservoir to determine the reservoir release through analysis of the rules contained within each zone. Figure 5 shows the definition of Grafton Pond’s “ExistingOps” operational zones, which consist of zones of Top of dam (1245.25 ft), Flood Control (1244.5 ft), Conservation (1239.5-1241.5 ft), and Inactive zone (1223.5 ft)<sup>1</sup>.

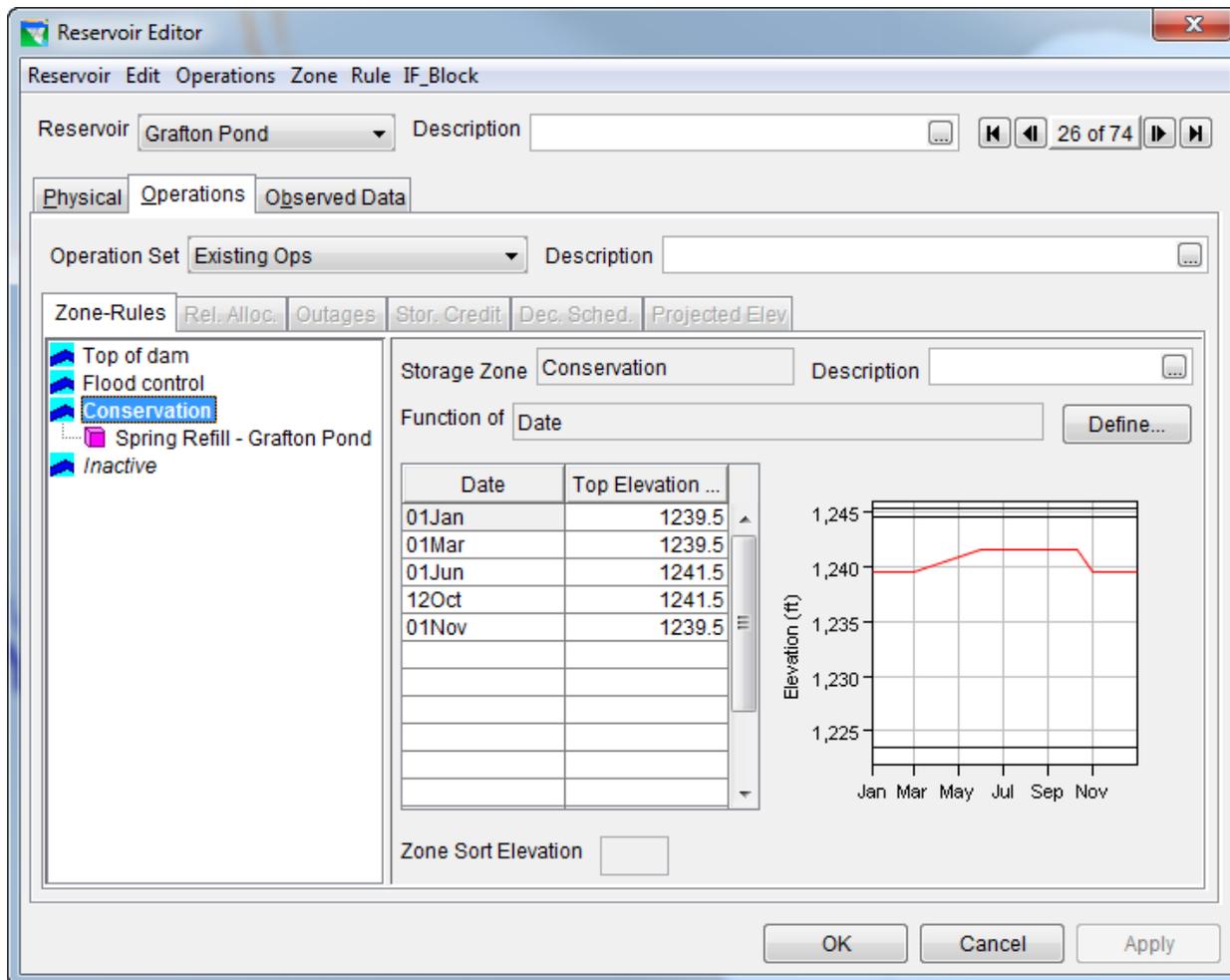


Figure 5: Reservoir Editor: Operations Tab –Existing Ops OpSet – Guide Curve

## B. Rule Illustrations

Figure 6 shows a set of operational rules specified for each zone that reflects the operation set named Existing Ops.

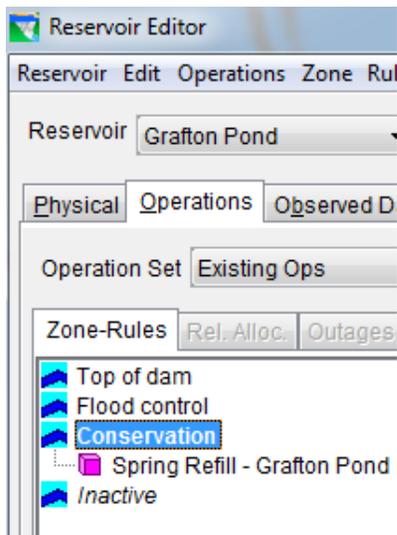


Figure 6: Reservoir Editor: Operations Tab – Existing Ops OpSet – Zones and Rules

## C. Rule Descriptions

### 1. Spring Refill-Grafton Pond

Figure 7 shows the content of “Spring Refill-Grafton Pond” rule. This rule defines the minimum release from reservoir as a function of Inflow.

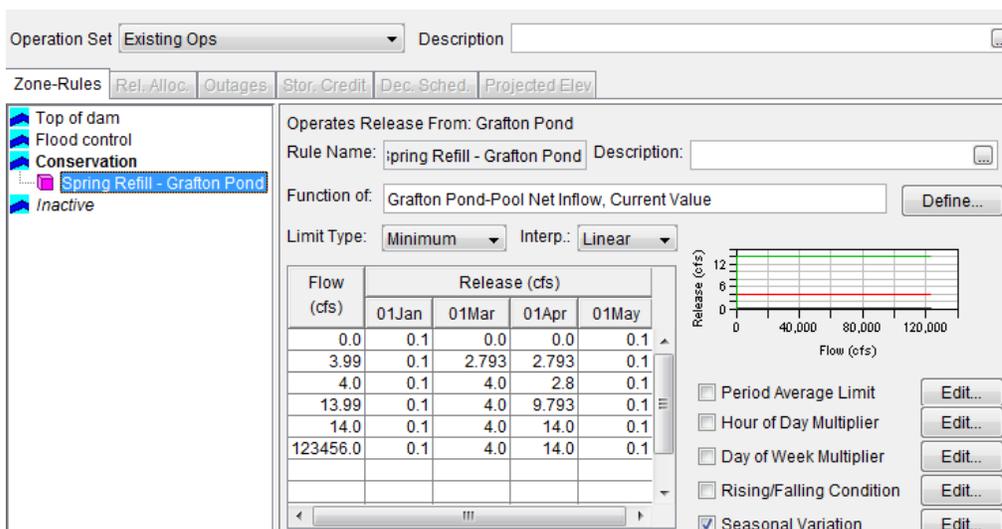


Figure 7: Reservoir Editor: Operations Tab – Existing Ops OpSet – Spring Refill-Grafton Pond

# Harriman

## I. Overview

Harriman dam is located upstream of the town of Readsboro on the Deerfield River. It is owned and operated by TransCanada Hydro Northeast Inc. for hydropower generation on a peaking, seasonal storage basis.

Figure 1 shows the location of Harriman Dam as it is represented in the HEC-ResSim model, and Figure 2 shows a photo from Harriman Dam.

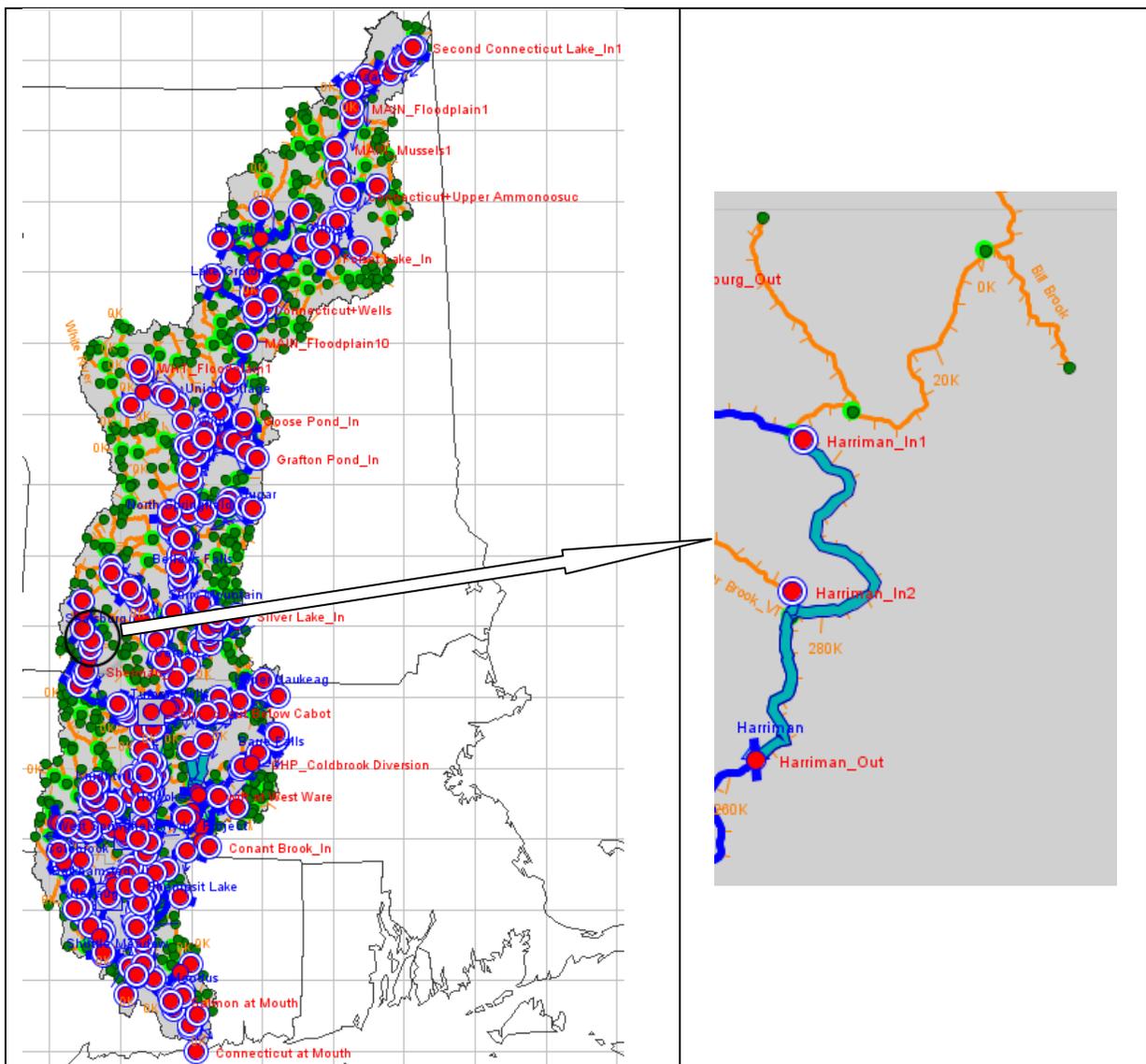


Figure 1: HEC-ResSim Map Display Showing Location of Harriman



**Figure 2: Photo of Harriman Dam**

## **II. Physical Characteristics**

The physical characteristics of the reservoir are separated between the Pool and the Dam in the HEC-ResSim model. The elevation-storage-area defines the pool as shown in Figure 3<sup>46</sup>. The dam consists of four types of outlets: (1) uncontrolled spillway, (2) controlled spillway, (3) Howell Bungler Valve, and (4) power plant as shown in Figure 4.

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<sup>46</sup> Data provided by TransCanada

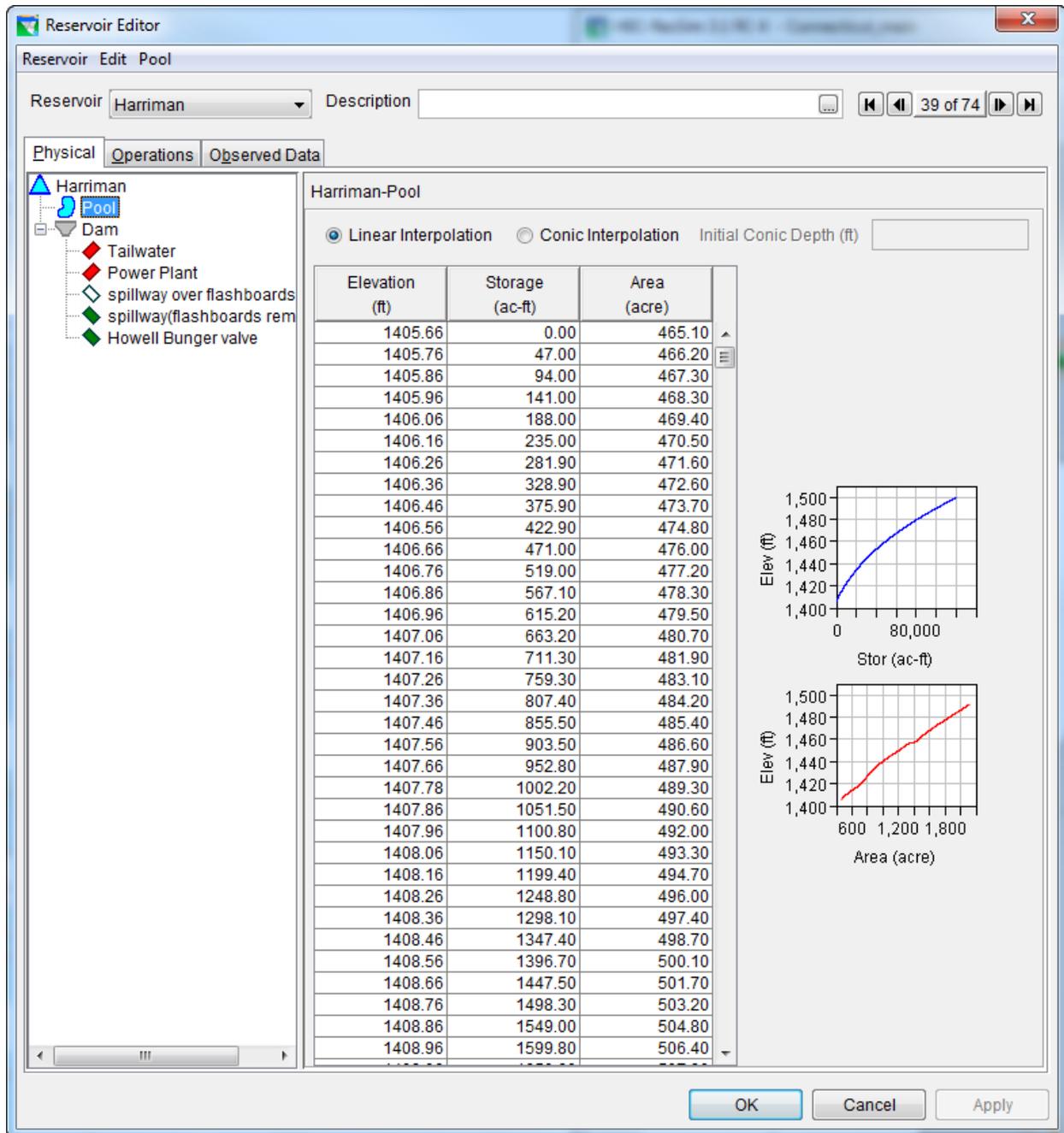


Figure 3: Reservoir Editor: Physical Tab -- Pool

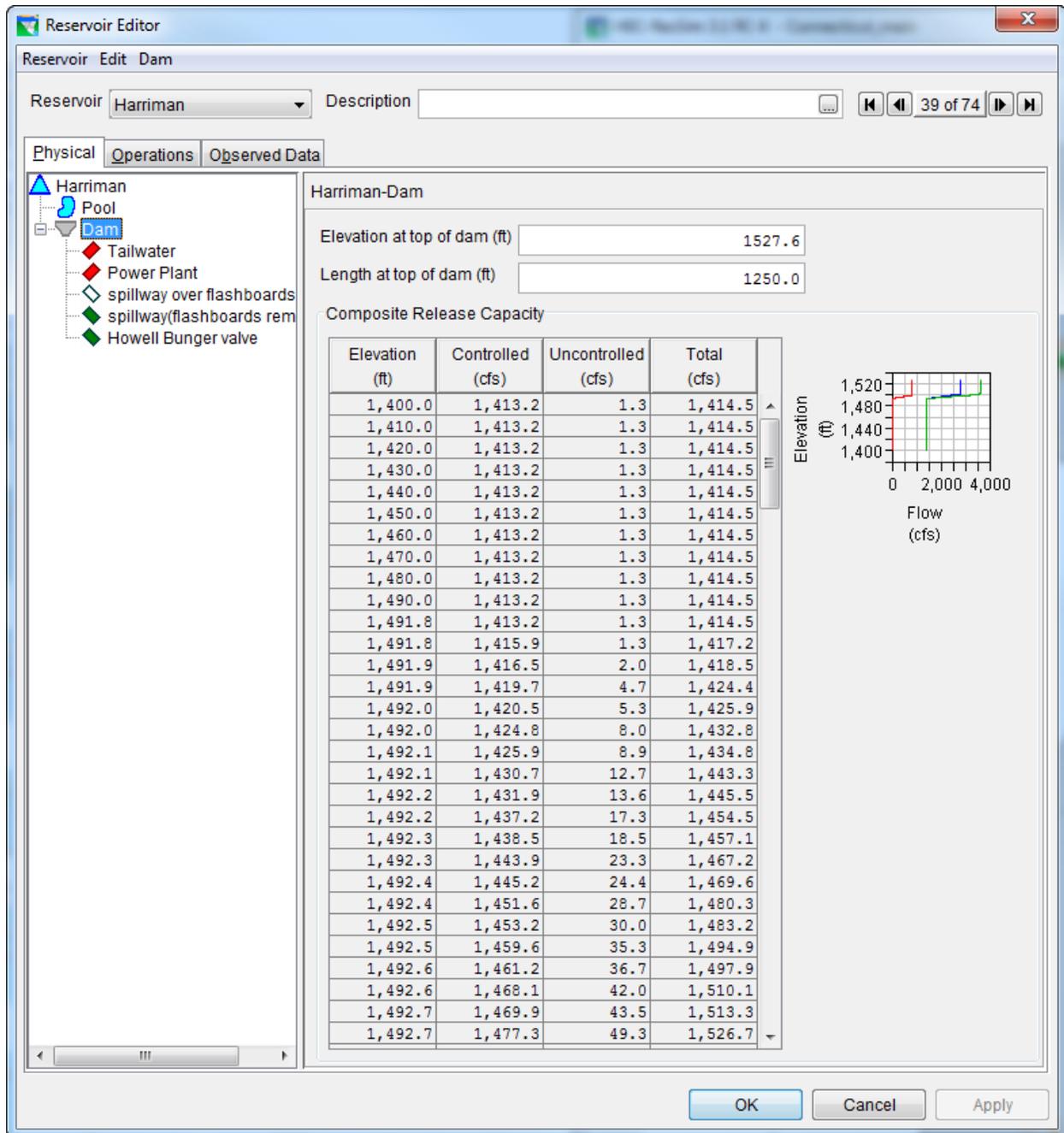


Figure 4: Reservoir Editor: Physical Tab -- Dam



Figure 6 shows a sequential release allocation approach specified for available outlets along Harriman Dam. The available outlets are given an order of priority for release. The power plant gets the release first until it reaches release capacity. The spillway gets the remainder of the release until it reaches capacity. After the capacity through the spillway is reached, the remainder of the release goes through the Howell Bunger Valve.

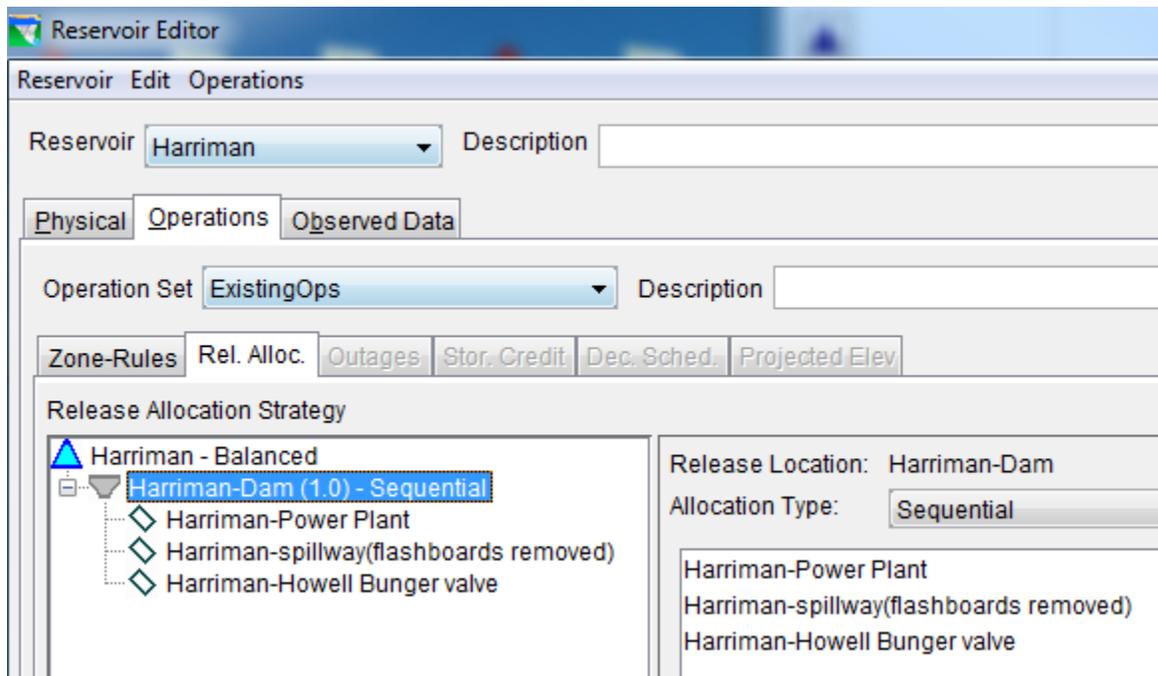


Figure 6: Reservoir Editor: Operations Tab – Existing Ops OpSet – Release Allocation

## B. Rule Illustrations

Figure 7 shows a set of operational rules specified for each zone that reflects the operation set named Existing Ops<sup>47</sup>.

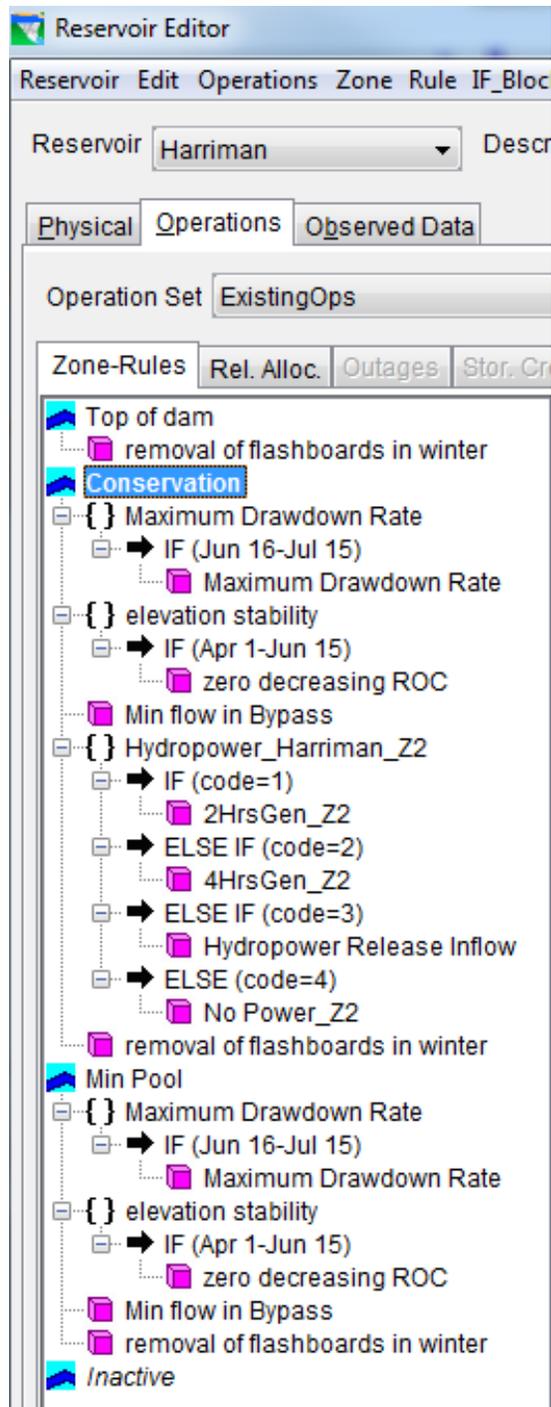


Figure 7: Reservoir Editor: Operations Tab – Existing Ops OpSet – Zones and Rules

<sup>47</sup> TransCanada. Deerfield River Operational Constraints. 2012.

## C. Rule Descriptions

### 1. Removal of flashboards in winter

Figure 8 shows the content of “removal of flashboards in winter” rule. This rule represents the releases through spillways when the flashboards are removed in winters.

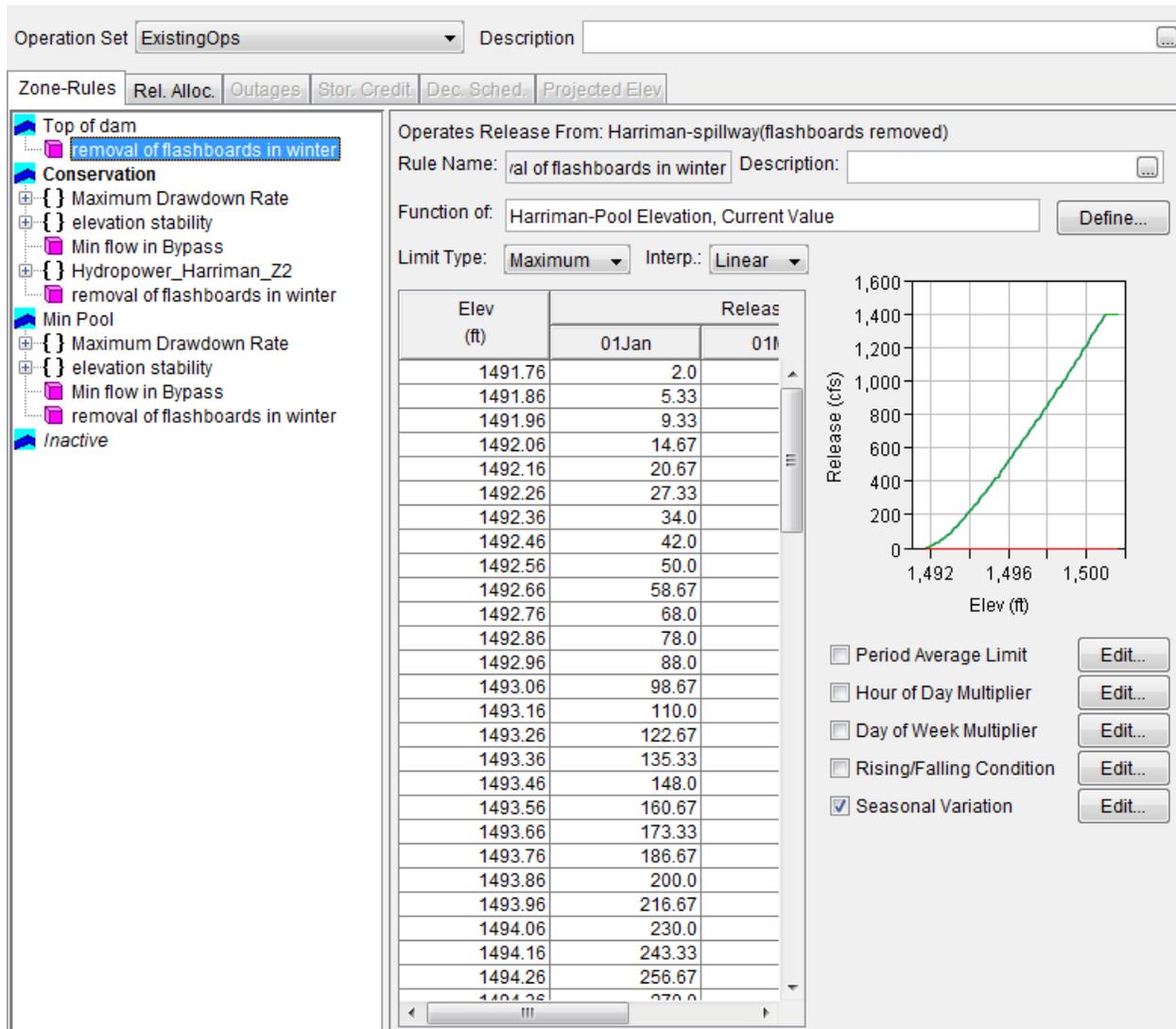


Figure 8: Reservoir Editor: Operations Tab – Existing Ops OpSet – removal of flashboards in winter

## 2. Maximum Drawdown Rate

Figure 9 shows the content of “Maximum Drawdown Rate” rule. This rule limits the maximum change of elevation during 16Jun-15Jul.

The screenshot displays the configuration of a rule named "Maximum Drawdown Rate" within the "ExistingOps" operation set. The interface is divided into two main sections.

**Top Section:**

- Operation Set:** ExistingOps
- Description:** Operates Release From: Harriman-spillway(flashboards removed)
- Name:** Maximum Drawdown Rate
- Description:** (empty)
- Table:**

Type	Name	Description
IF	Jun 16-Jul 15	

**Bottom Section:**

- Operation Set:** ExistingOps
- Description:** Operates Release From: Harriman-spillway(flashboards removed)
- IF Conditional:** Jun 16-Jul 15
- Description:** (empty)
- Table:**

	Value1		Value2
	Current Time Step	>=	16Jun
AND	Current Time Step	<=	15Jul
- Buttons:** Add Cond., Del. Cond.

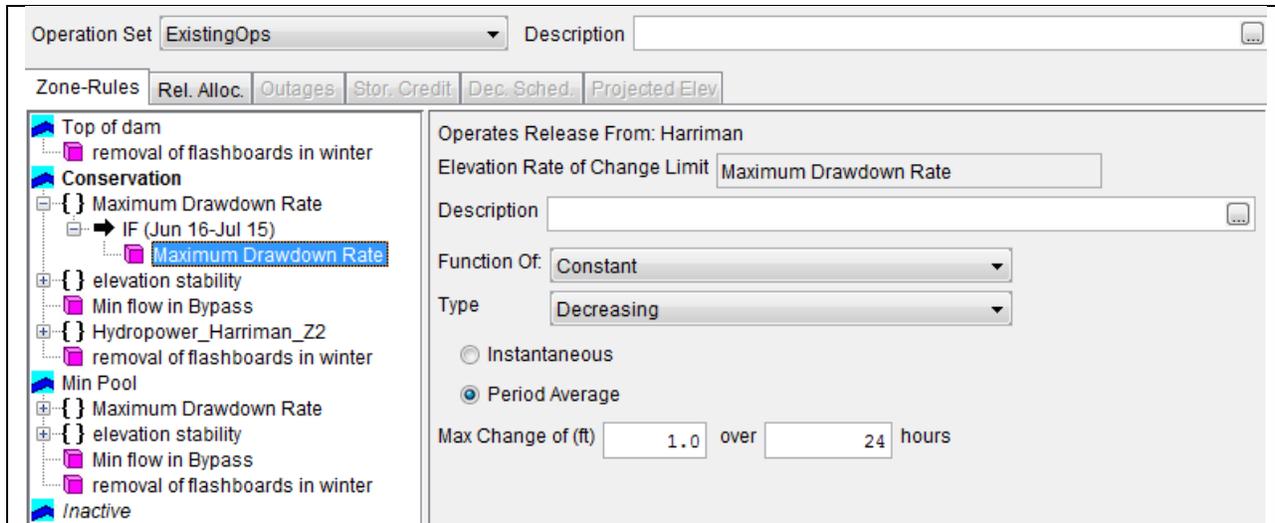
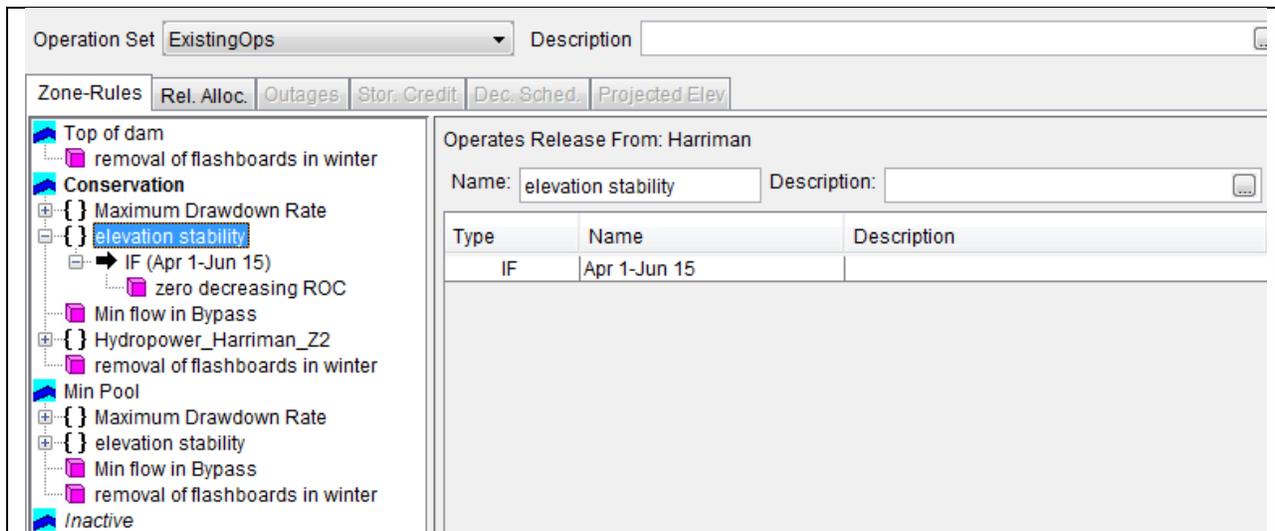


Figure 9: Reservoir Editor: Operations Tab – Existing Ops OpSet – Maximum Drawdown Rate

### 3. Elevation Stability

As Figure 10 shows this rule represents zero rate of change during Apr 1-Jun 15 for Harriman.



Operation Set: ExistingOps Description: [ ]

Zone-Rules: Rel. Alloc. Outages Stor. Credit Dec. Sched. Projected Eley

Operates Release From: Harriman

IF Conditional: Apr 1-Jun 15 Description: [ ]

	Value1		Value2
	Current Time Step	>=	01Apr
AND	Current Time Step	<=	15Jun

Buttons: Add Cond., Del. Cond.

---

Operation Set: ExistingOps Description: [ ]

Zone-Rules: Rel. Alloc. Outages Stor. Credit Dec. Sched. Projected Eley

Operates Release From: Harriman

Elevation Rate of Change Limit: zero decreasing ROC

Description: [ ]

Function Of: Constant

Type: Decreasing

Instantaneous  
 Period Average

Max Rate of Change (ft/hr): 0.0

Figure 10: Reservoir Editor: Operations Tab – Existing Ops OpSet – elevation stability

### 4. Hydropower\_Harriman\_Z2

This rule represents power strategy applied for Harriman reservoir. The content of the rule is shown in Figure 11 as per the peaking hydropower modeling strategy.

The figure displays three screenshots of a software interface for configuring the 'Hydropower\_Harriman\_Z2' rule. Each screenshot shows a tree view on the left and a configuration panel on the right.

**Top Screenshot:** Shows the rule configuration with the name 'Hydropower\_Harriman\_Z2'. The configuration panel includes a table for conditional logic:

Type	Name	Description
IF	code=1	
ELSE IF	code=2	
ELSE IF	code=3	
ELSE	code=4	

**Middle Screenshot:** Shows the 'IF Conditional' configuration for 'code=1'. The configuration panel includes a table for conditional values:

Value1	Value2
Harimann_Volume	= 1

**Bottom Screenshot:** Shows the 'Hydropower - Power Guide Curve Rule' configuration for '2HrsGen\_Z2'. The configuration panel includes a table for power storage and plant factor settings:

% Power Storage	Plant Factor (%)
0.0	0.0
100.0	8.33

Operation Set ExistingOps Description

Zone-Rules Rel. Alloc. Outages Stor. Credit Dec. Sched. Projected Elev.

Top of dam  
 removal of flashboards in winter  
**Conservation**  
 Maximum Drawdown Rate  
 elevation stability  
 Min flow in Bypass  
 Hydropower\_Harriman\_Z2  
 IF (code=1)  
 2HrsGen\_Z2  
**ELSE IF (code=2)**  
 4HrsGen\_Z2  
 ELSE IF (code=3)  
 Hydropower Release Inflow  
 ELSE (code=4)  
 No Power\_Z2

Operates Release From: Harriman-Power Plant  
 ELSE IF Conditional code=2 Description:

Value1		Value2
Harimann_Volume	=	2

Add Cond.  
Del. Cond.

---

Operation Set ExistingOps Description

Zone-Rules Rel. Alloc. Outages Stor. Credit Dec. Sched. Projected Elev.

Top of dam  
 removal of flashboards in winter  
**Conservation**  
 Maximum Drawdown Rate  
 elevation stability  
 Min flow in Bypass  
 Hydropower\_Harriman\_Z2  
 IF (code=1)  
 2HrsGen\_Z2  
 ELSE IF (code=2)  
**4HrsGen\_Z2**  
 ELSE IF (code=3)  
 Hydropower Release Inflow  
 ELSE (code=4)  
 No Power\_Z2

Operates Release From: Harriman-Power Plant  
 Hydropower - Power Guide Curve Rule 4HrsGen\_Z2  
 Description:  
 Zone at Top of Power Pool Conservation  
 Zone at Bottom of Power Pool Min Pool

% Power Storage	Plant Factor (%)
0.0	8.33
100.0	16.67

---

Operation Set ExistingOps Description

Zone-Rules Rel. Alloc. Outages Stor. Credit Dec. Sched. Projected Elev.

Top of dam  
 removal of flashboards in winter  
**Conservation**  
 Maximum Drawdown Rate  
 elevation stability  
 Min flow in Bypass  
 Hydropower\_Harriman\_Z2  
 IF (code=1)  
 2HrsGen\_Z2  
 ELSE IF (code=2)  
 4HrsGen\_Z2  
**ELSE IF (code=3)**  
 Hydropower Release Inflow  
 ELSE (code=4)  
 No Power\_Z2

Operates Release From: Harriman-Power Plant  
 ELSE IF Conditional code=3 Description:

Value1		Value2
Harimann_Volume	=	3

Add Cond.  
Del. Cond.

Operation Set ExistingOps Description

Zone-Rules Rel. Alloc. Outages Stor. Credit Dec. Sched. Projected Eley

Top of dam  
 removal of flashboards in winter  
 Conservation  
 Maximum Drawdown Rate  
 elevation stability  
 Min flow in Bypass  
 Hydropower\_Harriman\_Z2  
      IF (code=1)  
          2HrsGen\_Z2  
      ELSE IF (code=2)  
          4HrsGen\_Z2  
      ELSE IF (code=3)  
          Hydropower Release Inflow  
      ELSE (code=4)  
          No Power\_Z2  
 removal of flashboards in winter  
 Min Pool  
 Maximum Drawdown Rate  
 elevation stability  
 Min flow in Bypass  
 removal of flashboards in winter

Operates Release From: Harriman-Power Plant  
 Rule Name: ydropower Release Inflow Description:  
 Function of: Harriman-Pool Net Inflow, Current Value Define...  
 Limit Type: Minimum Interp.: Linear

Flow (cfs)	Release (cfs)
0.0	0.0
100000.0	100000.0

Operation Set ExistingOps Description

Zone-Rules Rel. Alloc. Outages Stor. Credit Dec. Sched. Projected Eley

Top of dam  
 removal of flashboards in winter  
 Conservation  
 Maximum Drawdown Rate  
 elevation stability  
 Min flow in Bypass  
 Hydropower\_Harriman\_Z2  
      IF (code=1)  
          2HrsGen\_Z2  
      ELSE IF (code=2)  
          4HrsGen\_Z2  
      ELSE IF (code=3)  
          Hydropower Release Inflow  
      ELSE (code=4)  
          No Power\_Z2

Operates Release From: Harriman-Power Plant  
 ELSE Conditional code=4 Description:

Operation Set ExistingOps Description

Zone-Rules Rel. Alloc. Outages Stor. Credit Dec. Sched. Projected Eley

Top of dam  
 removal of flashboards in winter  
 Conservation  
 Maximum Drawdown Rate  
 elevation stability  
 Min flow in Bypass  
 Hydropower\_Harriman\_Z2  
      IF (code=1)  
          2HrsGen\_Z2  
      ELSE IF (code=2)  
          4HrsGen\_Z2  
      ELSE IF (code=3)  
          Hydropower Release Inflow  
      ELSE (code=4)  
          No Power\_Z2

Operates Release From: Harriman-Power Plant  
 Hydropower - Power Guide Curve Rule No Power\_Z2  
 Description:  
 Zone at Top of Power Pool Conservation  
 Zone at Bottom of Power Pool Min Pool

% Power Storage	Plant Factor (%)
0.0	0.0
100.0	0.0

Figure 11: Reservoir Editor: Operations Tab – Existing Ops OpSet – Hydropower\_Hariman\_Z2

Figure 12 describes the definition of codes used in the Harriman\_Volume state variable. The code is summing up the current Inflow and previous storage in each time step, compare it to the volume needed for generating 2 and 4 hours power and to the spillway storage minus inactive storage and then decide how much to release.

```

State Variable Editor
StateVariable Edit
Name: Harrimann_Volume Description:
Parameter Name: code Parameter Type: Code Always Com
Initialization Main CleanUp
TimeSeries
Model Variab
State Variabl
APIs
Math
HecTime
Network
RunTimeSte
RunTimeWir
StateVariable
TimeSeries
DSS
DSSFile
1 # Create a code to track the available water for generating power
2
3 #The code is summing up the current Inflow and previous storage in each timestep,compare it to the volume needed for
4 #generating 2 and 4 hours power and to the spillway storage minus inactive storage and then decide how much to release.
5
6 # Code =0: I+S >S (spillway storage)-S (inactive storage)
7 # code =1:0< I+S<V(2hrs.Gen)
8 # code =2: V(2hrs.Gen)<I+S<V(4hrs.Gen)
9 # code =3: V(4hrs.Gen)<I+S
10
11 # S (spillway storage)-S (inactive storage)=318000-227611.57=90388 (acf)
12 #outlet capacity=1411.2 (cfs)
13 #V(2hrs.Gen)=(2*outlet capacity)*0.082=231.4368 (acf)
14 #V(4hrs.Gen)=(4*outlet capacity)*0.082=462.8766 (acf)
15
16 from hec.model import RunTimeStep
17
18 Inflow_TS=network.getTimeSeries("Reservoir","Harriman", "Pool", "Flow-IN NET")
19 Inflow= Inflow_TS.getCurrentValue (currentRuntimestep)
20 Inflow_acf=Inflow*1.98
21
22 Storage_TS = network.getTimeSeries("Reservoir","Harriman", "Pool", "Stor")
23 Storage=Storage_TS.getPreviousValue (currentRuntimestep)
24
25 Volume=Inflow_acf+(Storage-227611.57)
26
27 if Volume >= 90388:
28     Code=0
29 elif 0<Volume <=231.4368 :
30     Code=1
31 elif 231.4368<Volume <=462.8766:
32     Code=2
33 elif 462.8766<Volume<90388:
34     Code=3
35 else:
36     Code=4
37
38 currentVariable.setValue (currentRuntimestep, Code)

```

Figure 12: State Variable Editor: Harriman\_Volume

### 5. Min Flow in Bypass

Figure 13 shows the content of Min Flow in Bypass. This rule represents the seasonal minimum flow releases required from Harriman.

The screenshot displays the 'Operations Tab' for the 'ExistingOps' OpSet. The 'Min flow in Bypass' rule is selected in the tree view. The configuration panel shows the following details:

- Operates Release From:** Harriman
- Rule Name:** Min flow in Bypass
- Description:** (empty)
- Function of:** Harriman-Pool Net Inflow, Current Value
- Limit Type:** Minimum
- Interp.:** Linear

The central table defines the release flow (cfs) based on the reservoir flow (cfs) and the date:

Flow (cfs)	Release (cfs)		
	01Jan	01Jul	01Oct
0.0	70.0	57.0	70.0
123456.0	70.0	57.0	70.0

To the right of the table is a graph showing 'Release (cfs)' on the y-axis (ranging from 56 to 72) and 'Flow (cfs)' on the x-axis (ranging from 0 to 120,000). A horizontal green line is plotted at approximately 70 cfs, and a horizontal red line is plotted at approximately 57 cfs.

The right sidebar contains several options with 'Edit...' buttons:

- Period Average Limit
- Hour of Day Multiplier
- Day of Week Multiplier
- Rising/Falling Condition
- Seasonal Variation

Figure 13: Reservoir Editor: Operations Tab – Existing Ops OpSet – Min flow in Bypass



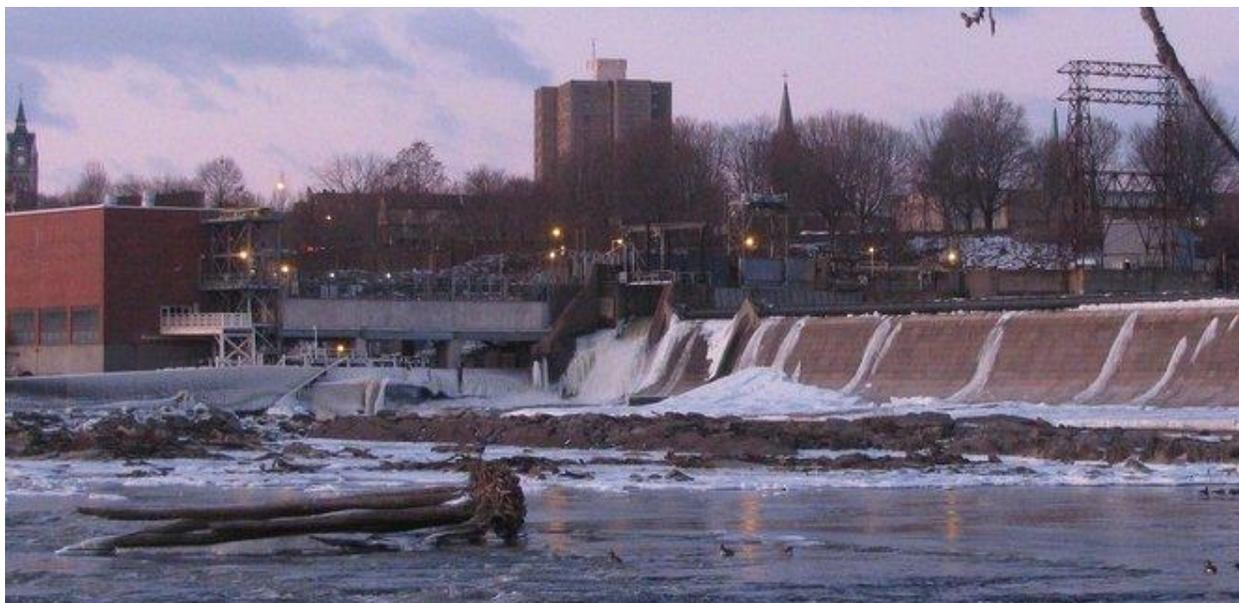


Figure 2: Photo from Holyoke dam

## II. Physical Characteristics

The physical characteristics of the reservoir are separated between the Pool and the Dam in the HEC-ResSim model. The elevation-storage-area defines the pool as shown in Figure 3<sup>48</sup>. The dam consists of five types of outlets: (1) controlled Bascule Gate, (2) controlled Bypass pipe, (3) controlled Canal System, (4) controlled Spillway with gates, and (5) power plant as shown in Figure 4.

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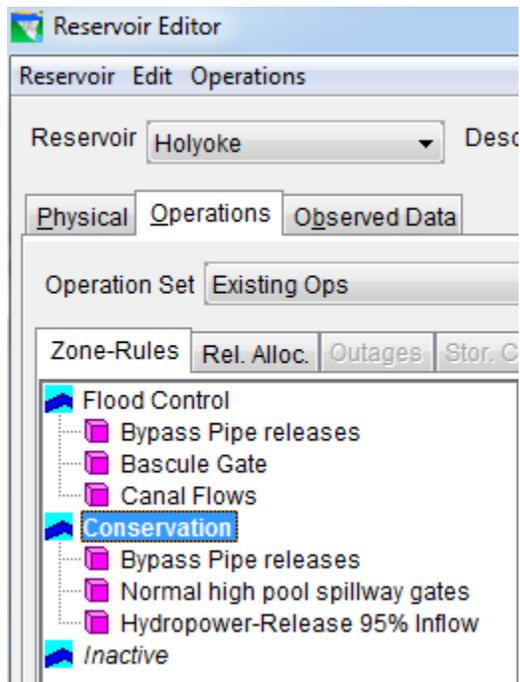
<sup>48</sup>Data provided by UMASS





## B. Rule Illustrations

Figure 7 shows a set of operational rules specified for each zone that reflects the operation set named Existing Ops<sup>1</sup>.



**Figure 7: Reservoir Editor: Operations Tab – Existing Ops OpSet – Zones and Rules**

Figure 8 shows a sequential release allocation approach specified for available outlets along Bellows Falls Dam. The available outlets are given an order of priority for release. The power plant gets the release first until it reaches release capacity. The Bypass pipe gets the remainder of the release until it reaches capacity. Then the flow passes through the Canal System. After the capacity through the Canal System is reached, the remainder of the release goes through the Bascule gate and spillway with gates, respectively.

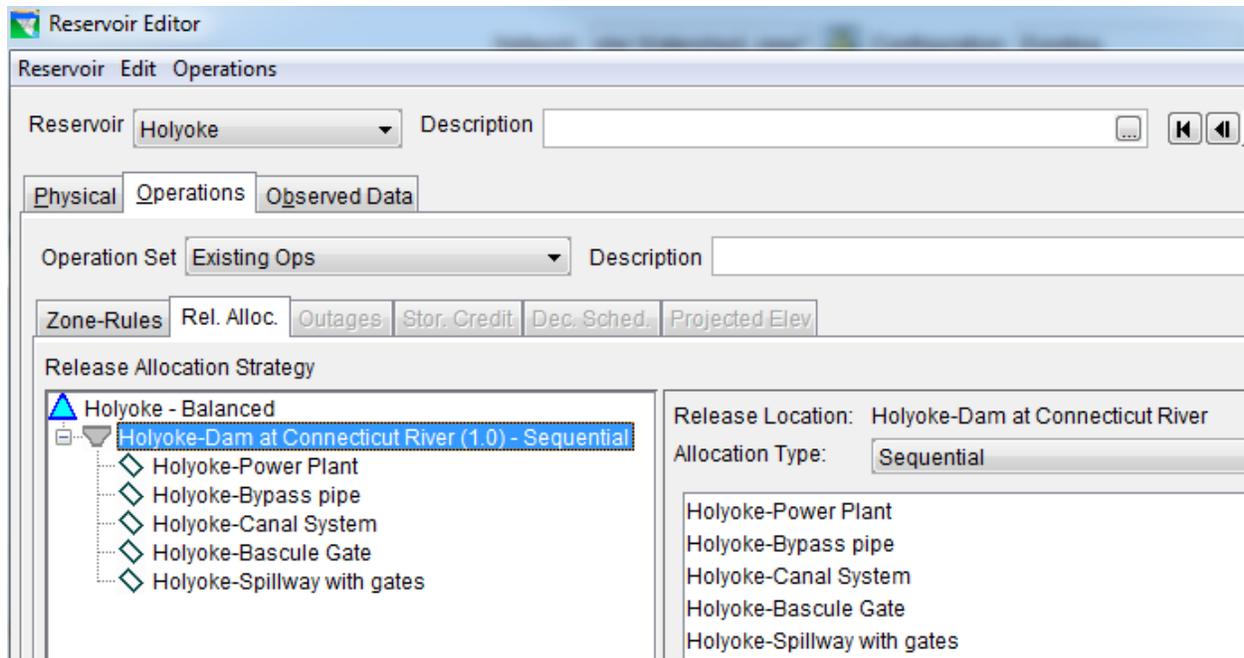


Figure 8: Reservoir Editor: Operations Tab – Existing Ops OpSet – Release Allocation

## C. Rule Descriptions

### 1. Bypass Pipe release

Figure 9 shows the content of “Bypass Pipe release” rule. This rule represents a specified release from Bypass pipe controlled outlet.

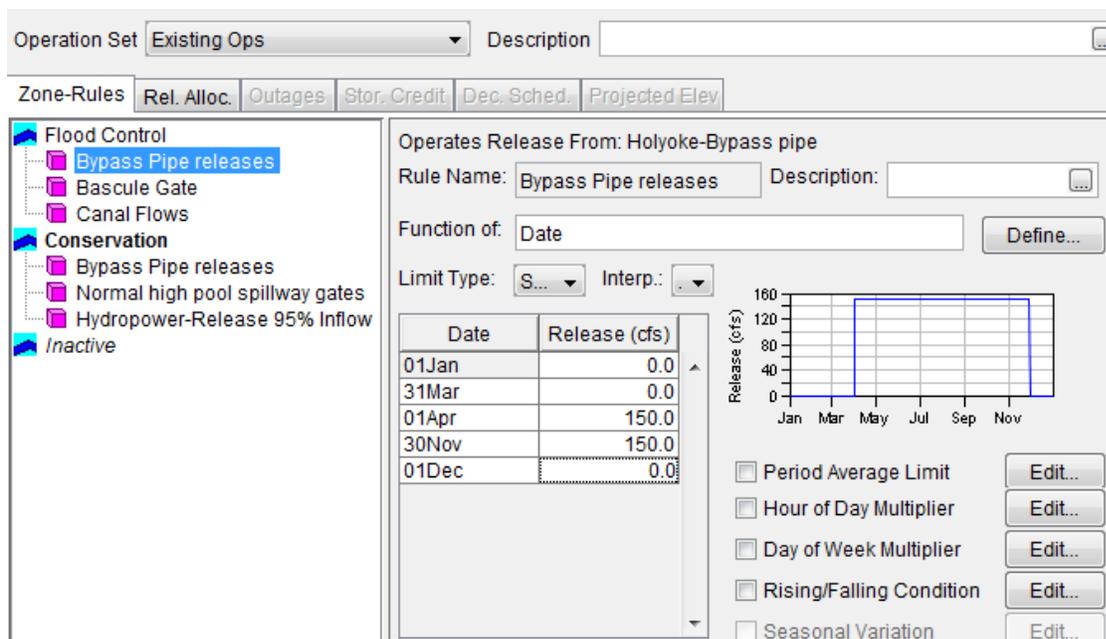


Figure 9: Reservoir Editor: Operations Tab – Existing Ops OpSet – Bypass Pipe release

### 2. Bascule Gate

Figure 10 shows the content of “Bascule Gate” rule. This rule represents the seasonal minimum release from Bascule gate controlled outlet.

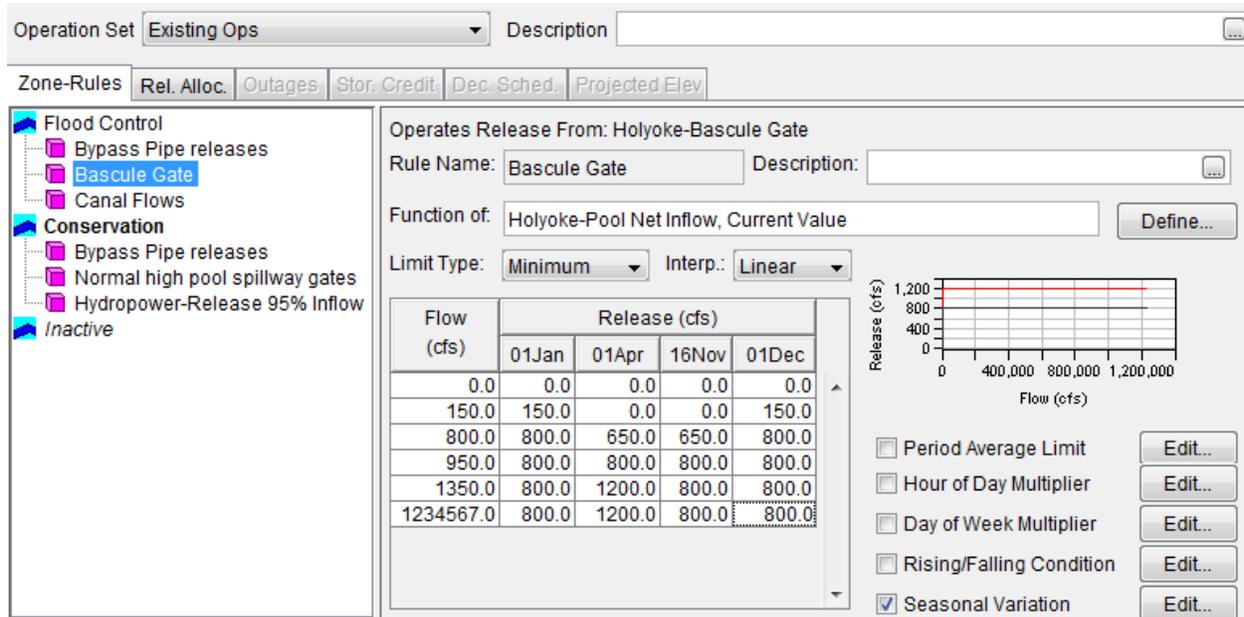


Figure 10: Reservoir Editor: Operations Tab – Existing Ops OpSet – Bascule Gate

### 3. Canal Flows

Figure 11 shows the content of “Canal Flows” rule. This rule represents the seasonal minimum release from Canal System controlled outlet.

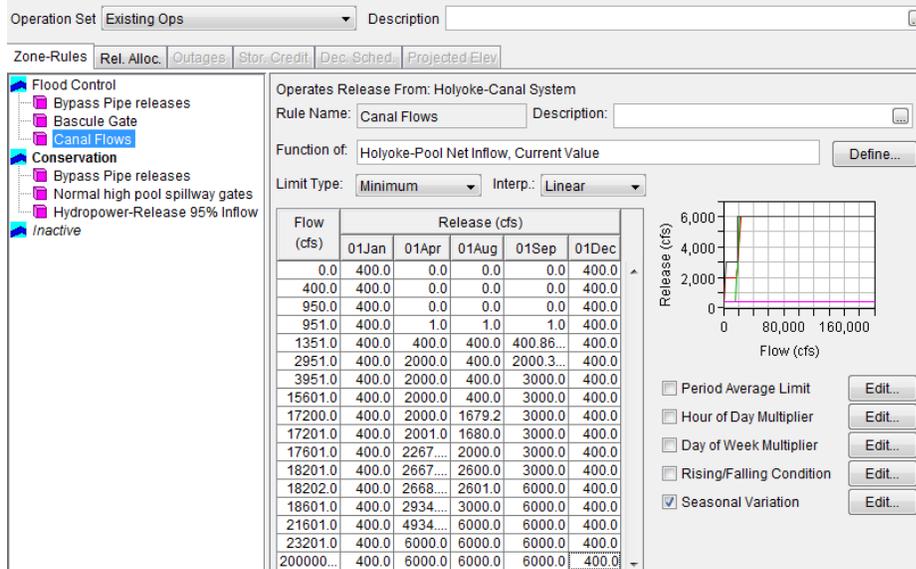


Figure 11: Reservoir Editor: Operations Tab – Existing Ops OpSet – Canal Flows

#### 4. Normal high pool spillway gates

Figure 12 shows the content of “Normal high pool spillway gates” rule. This rule makes no releases from Spillway with gates controlled outlet.

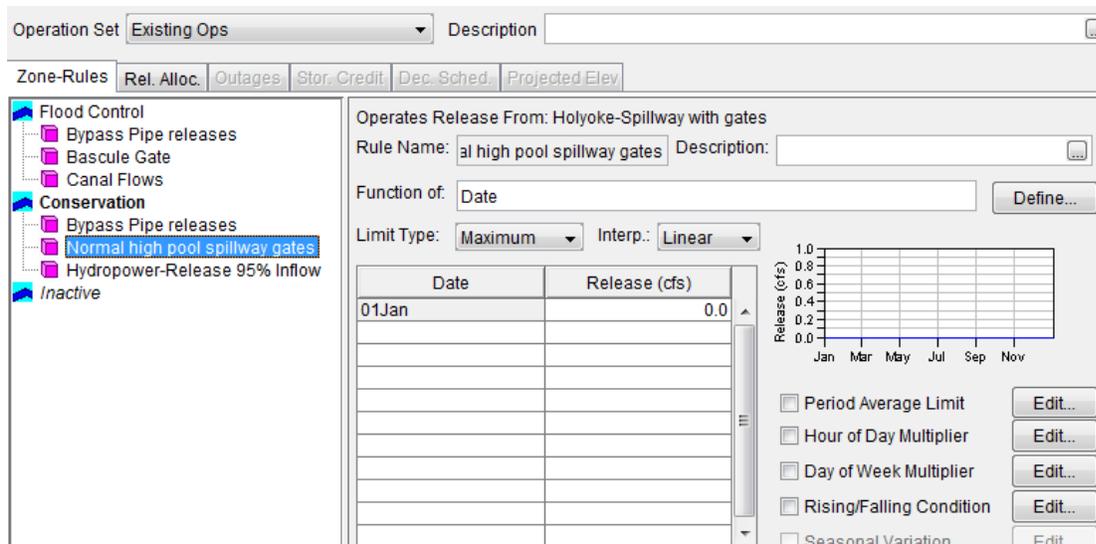


Figure 12: Reservoir Editor: Operations Tab – Existing Ops OpSet – Normal high pool spillway gates

#### 5. Hydropower-Release 95% Inflow

Figure 13 shows the content of “Hydropower –Release 95% Inflow” rule. This rule releases the 95% of inflow through power plant as per the run-of-river modeling strategy.

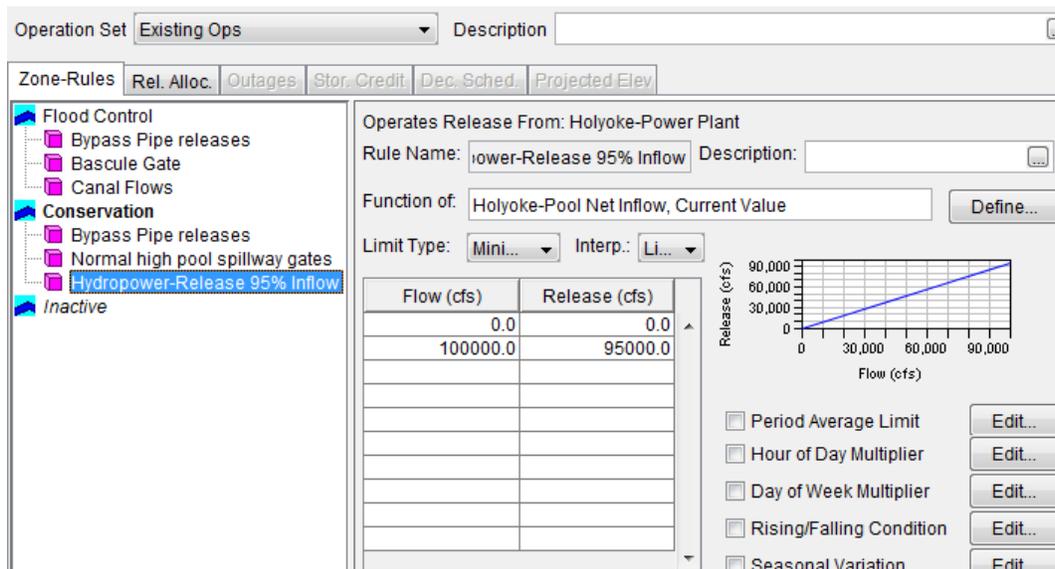


Figure 13: Reservoir Editor: Operations Tab – Existing Ops OpSet – Hydropower-Release 95% Inflow

# Knightville

## I. Overview

Knightville Dam is located on the North Branch of the Westfield River near the town of Knightville in Hampshire County, Massachusetts, USA. The U.S. Army Corps of Engineers constructed the dam in 1941 and is still owned and operated by the Corps. It is primarily used for flood control but also for recreation.

Figure 1 shows the location of Knightville Dam as it is represented in the HEC-ResSim model. Figure 2 shows a photo of the dam.

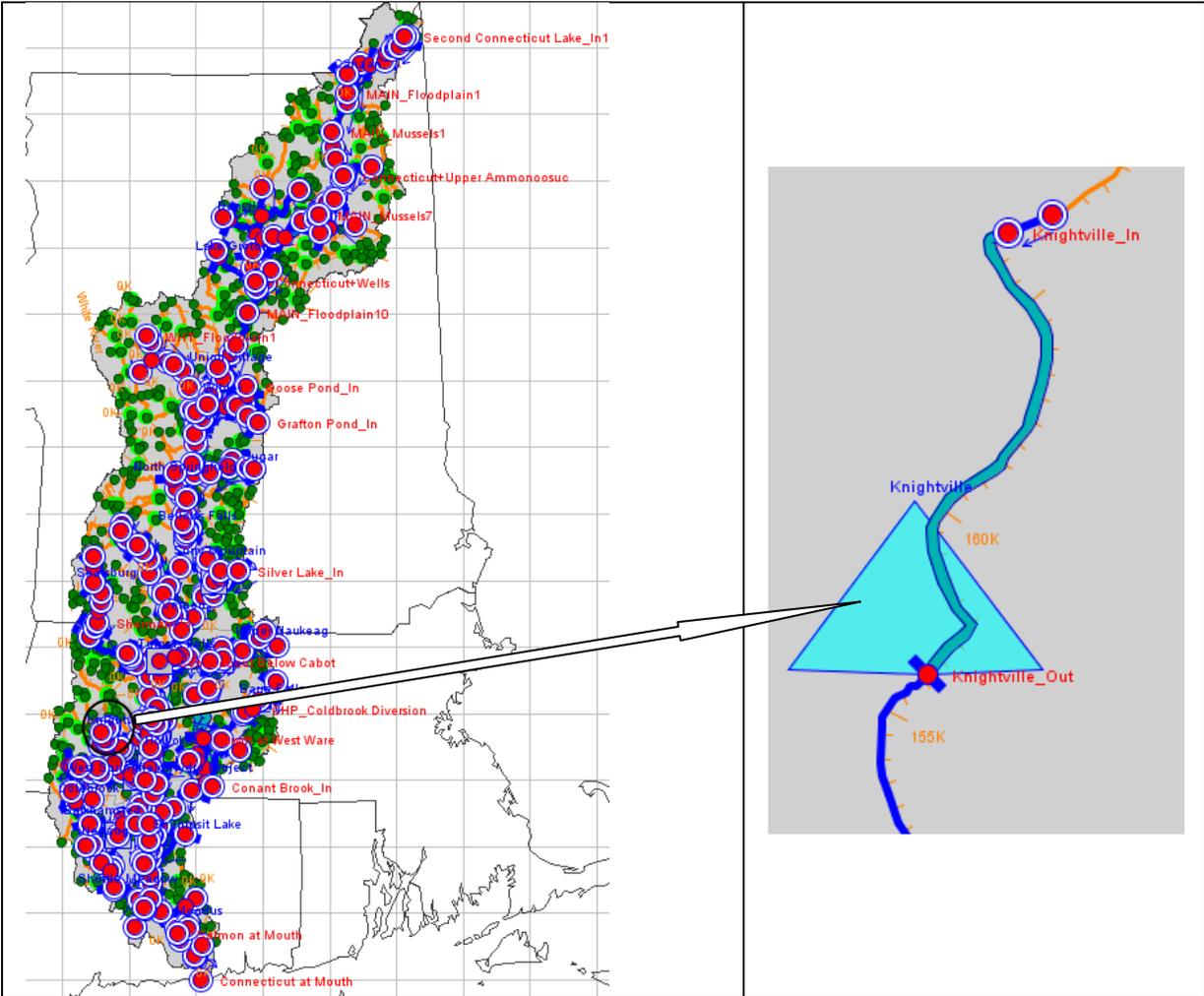


Figure 1: HEC-ResSim Map Display Showing Location of Knightville dam



**Figure 2: Photo of Knightville Dam**

## **II. Physical Characteristics**

The physical characteristics of the reservoir are separated between the Pool and the Dam in the HEC-ResSim model. The elevation-storage-area defines the pool as shown in Figure 3. The dam consists of two types of outlets: (1) controlled slide gates, and (2) uncontrolled spillway, as shown in Figure 4. All physical and operations data were provided by US Army Corps New England District, through both a previously created ResSim model and the Reservoir Regulation Team website<sup>49</sup>.

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<sup>49</sup> [http://rsgisias.crrel.usace.army.mil/nae/cwms\\_map.map\\_index](http://rsgisias.crrel.usace.army.mil/nae/cwms_map.map_index)

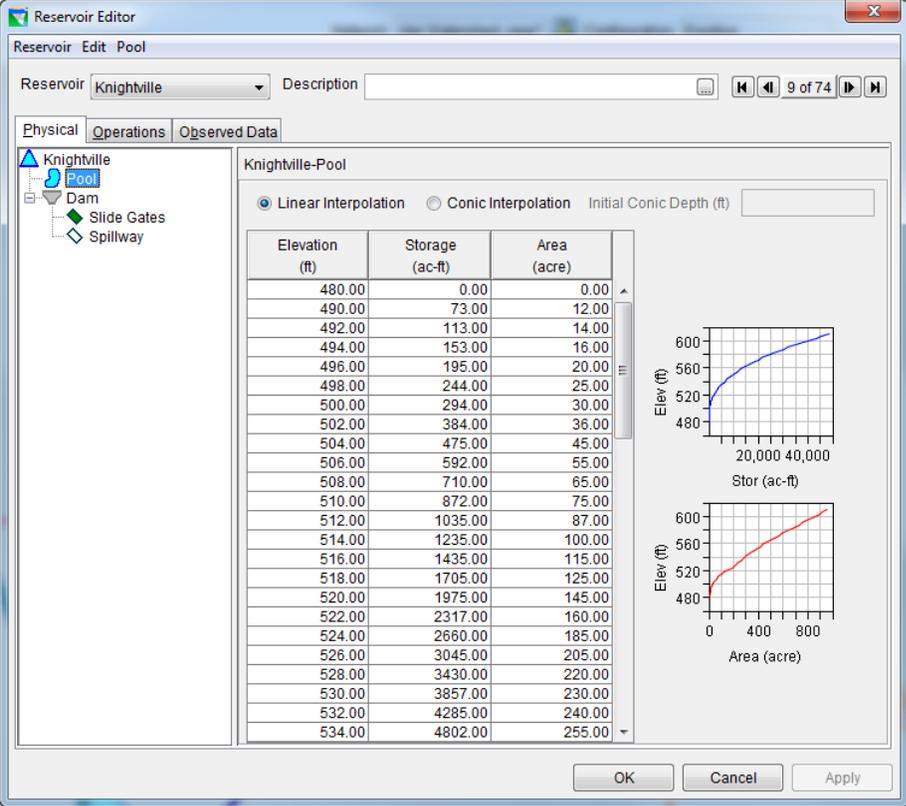


Figure 3: Reservoir Editor: Physical Tab -- Pool

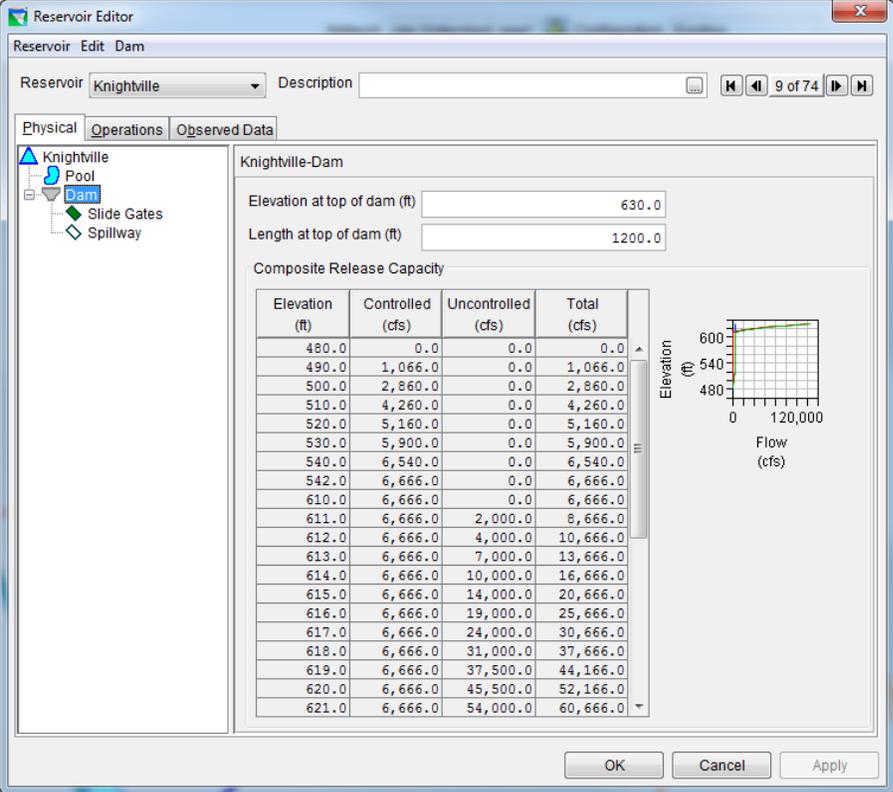


Figure 4: Reservoir Editor: Physical Tab -- Dam

### III. Operations

#### A. Operation Set

Zones are used to define the operational storage in the reservoir to determine the reservoir release through analysis of the rules contained within each zone. Figure 5 shows the definition of Knightsville’s “ExistingOps” operational zones, which consist of zones of Surcharge (630 ft), Flood Control (610 ft), Conservation (481-505 ft), and Inactive zone (480 ft).

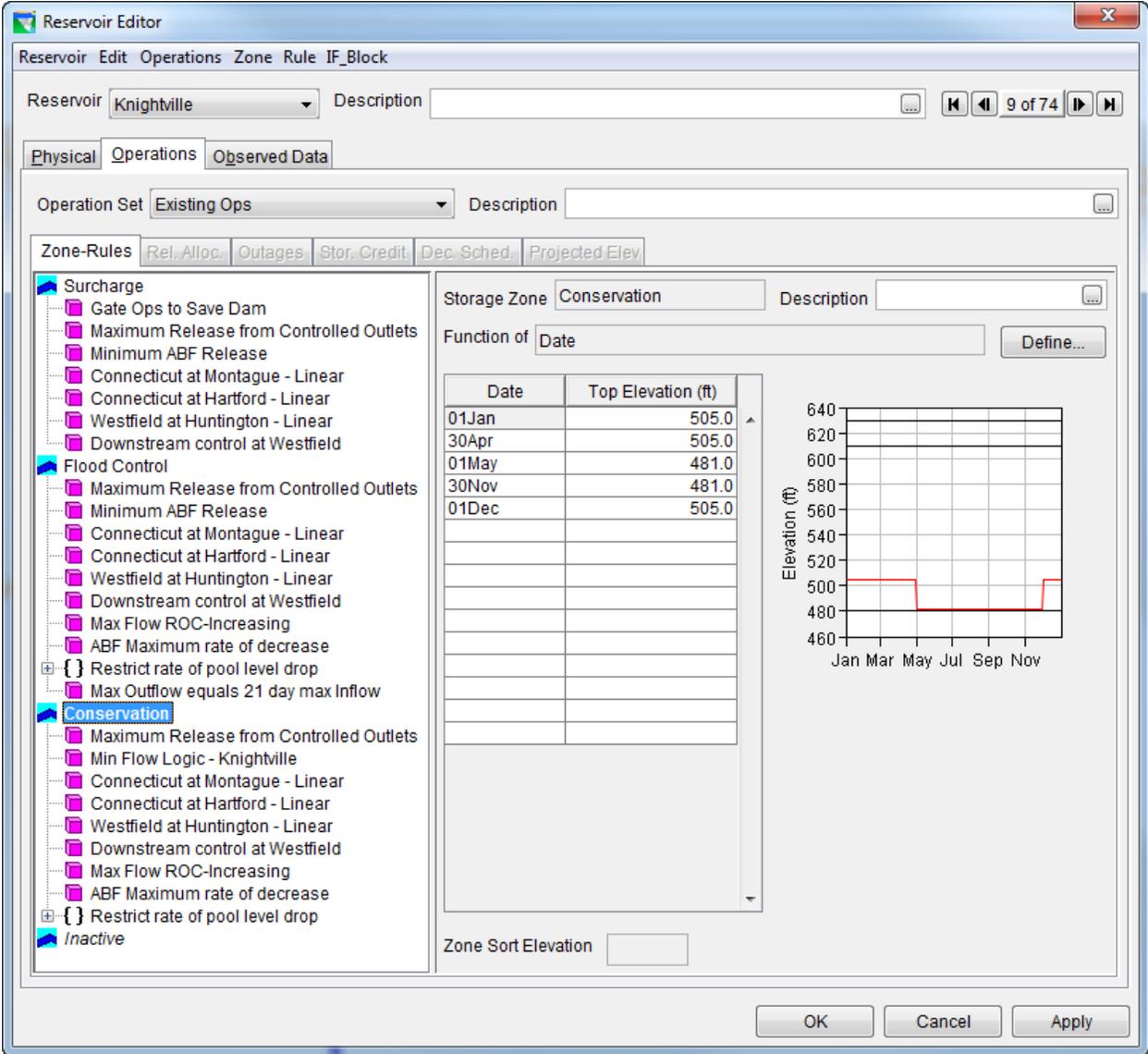


Figure 5: Reservoir Editor: Operations Tab –Existing Ops OpSet – Guide Curve

### B. Rule Illustrations

Figure 6 shows a set of operational rules specified for each zone that reflects the operation set named Existing Ops. As described in the Simulation/Verification section of the report, adjustments were made to the operations to closer match gauge data.

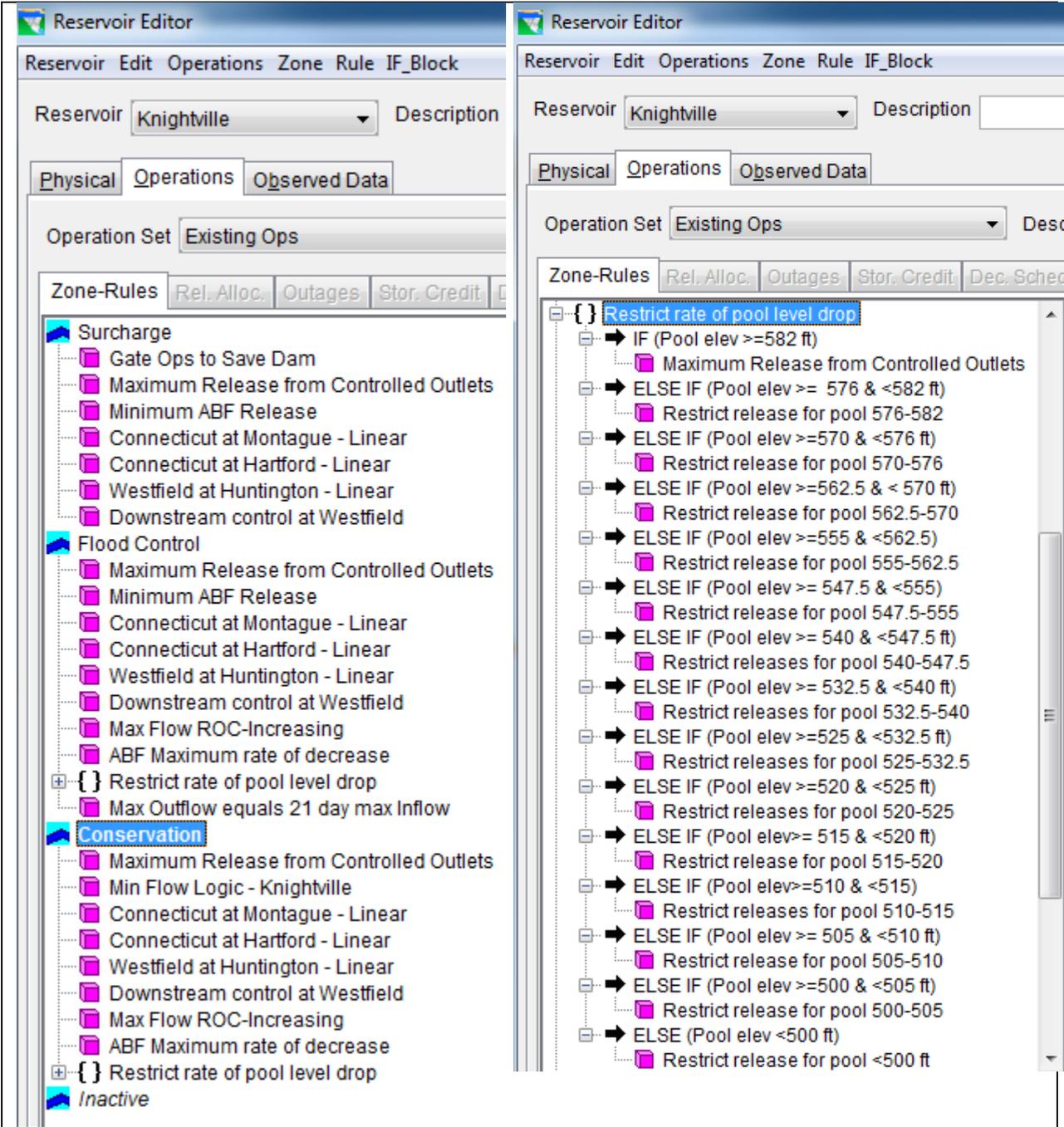


Figure 6: Reservoir Editor: Operations Tab – Existing Ops OpSet – Zones and Rules

### C. Rule Descriptions

#### 1. Gate Ops to Save Dam

Figure 7 shows the content of “Gate Ops to Save Dam” rule. This rule represents the maximum allowable release from Slide gates as a function of pool elevation when the pool is in Surcharge zone.

Operation Set: Existing Ops | Description: [ ]

Zone-Rules: Rel. Alloc. | Outages | Stor. Credit | Dec. Sched. | Projected Elev

- Surcharge
  - Gate Ops to Save Dam**
  - Maximum Release from Controlled Outlets
  - Minimum ABF Release
  - Connecticut at Montague - Linear
  - Connecticut at Hartford - Linear
  - Westfield at Huntington - Linear
  - Downstream control at Westfield
- Flood Control
  - Maximum Release from Controlled Outlets
  - Minimum ABF Release
  - Connecticut at Montague - Linear
  - Connecticut at Hartford - Linear
  - Westfield at Huntington - Linear
  - Downstream control at Westfield
  - Max Flow ROC-Increasing
  - ABF Maximum rate of decrease
  - Restrict rate of pool level drop
  - Max Outflow equals 21 day max Inflow
- Conservation
  - Maximum Release from Controlled Outlets
  - Min Flow Logic - Knightville
  - Connecticut at Montague - Linear
  - Connecticut at Hartford - Linear
  - Westfield at Huntington - Linear
  - Downstream control at Westfield
  - Max Flow ROC-Increasing
  - ABF Maximum rate of decrease
  - Restrict rate of pool level drop
- Inactive

Operates Release From: Knightville-Slide Gates

Rule Name: Gate Ops to Save Dam | Description: [ ]

Function of: Pool Elevation, Period Average, 0.0 hr lag, 48.0 hr period | Define...

Limit Type: Maxi... | Interp.: Li...

Elev (ft)	Release (cfs)
610.0	4500.0
611.0	2500.0
612.0	500.0
614.0	400.0
616.0	1200.0
618.0	1300.0
620.0	8100.0
622.0	14000.0
630.0	14500.0

Graph: Release (cfs) vs Elev (ft)

- Period Average Limit | Edit...
- Hour of Day Multiplier | Edit...
- Day of Week Multiplier | Edit...
- Rising/Falling Condition | Edit...
- Seasonal Variation | Edit...

Figure 7: Reservoir Editor: Operations Tab – Existing Ops OpSet –Gate Ops to Save Dam





4. Connecticut at Montague-Linear

Figure 10 shows the content of “Connecticut at Montague-Linear” rule. This rule represents the maximum allowable release from the dam as a function of the previous day stage at Montague. The previous day stage was used to account for the delay that occurs between the stage exceeding the specified target and the change in operations at the flood control dams that occurs in reality.

The screenshot shows the 'Reservoir Editor' interface. At the top, the 'Operation Set' is 'Existing Ops'. Below this are tabs for 'Zone-Rules', 'Rel. Alloc.', 'Outages', 'Stor. Credit', 'Dec. Sched.', and 'Projected Eley'. The left sidebar shows a tree view of rules, with 'Connecticut at Montague - Linear' selected under the 'Flood Control' category. The main panel displays the configuration for this rule: 'Operates Release From: Knightville', 'Rule Name: cicut at Montague - Linear', and 'Function of: Connecticut at Montague Stage, Previous Value'. The 'Limit Type' is 'Maxi...' and 'Interp.' is 'Li...'. A table shows the release limits for various stages, and a graph plots Release (cfs) against Stage (ft). Below the graph are several checkboxes for advanced settings like 'Period Average Limit', 'Hour of Day Multiplier', etc.

Stage (ft)	Release (cfs)
0.0	4500.0
26.0	4500.0
27.0	3600.0
28.0	2700.0
29.0	1800.0
30.0	900.0
31.0	0.0
50.0	0.0

Figure 10: Reservoir Editor: Operations Tab – Existing Ops OpSet – Connecticut at Montague-Linear

5. Connecticut at Hartford-Linear

Figure 11 shows the content of “Connecticut at Hartford-Linear” rule. This rule represents the maximum allowable release from dam as a function of previous day stage at Hartford. The previous day stage was used to account for the delay that occurs between the stage exceeding the specified target and the change in operations at the flood control dams that occurs in reality.

The screenshot shows the 'Operations Tab' in the Reservoir Editor. The 'Existing Ops' set is selected. The 'Connecticut at Hartford-Linear' rule is highlighted in the tree view. The rule configuration is as follows:

- Operates Release From: Knightsville
- Rule Name: Connecticut at Hartford - Linear
- Function of: Connecticut at Hartford Stage, Previous Value
- Limit Type: Maximum
- Interpolation: Linear

Stage (ft)	Release (cfs)
0.0	4500.0
18.0	4500.0
19.0	3600.0
20.0	2700.0
21.0	1800.0
22.0	900.0
23.0	0.0
50.0	0.0

The graph shows a step function where release is constant at 4500 cfs until stage 18 ft, then drops to 3600 cfs at 19 ft, 2700 cfs at 20 ft, 1800 cfs at 21 ft, 900 cfs at 22 ft, and 0 cfs at 23 ft, remaining at 0 cfs up to 50 ft.

Figure 11: Reservoir Editor: Operations Tab – Existing Ops OpSet – Connecticut at Montague-Linear

### 6. Westfield at Huntington-Linear

Figure 12 shows the content of “Westfield at Huntington-Linear” rule. This rule represents the maximum allowable release from dam as a function of previous day stage at Huntington. The previous day stage was used to account for the delay that occurs between the stage exceeding the specified target and the change in operations at the flood control dams that occurs in reality.

The screenshot shows the 'Operations Tab' in the Reservoir Editor. The 'Operation Set' is 'Existing Ops'. The 'Zone-Rules' list on the left includes 'Surchage', 'Flood Control', and 'Conservation'. The 'Westfield at Huntington - Linear' rule is selected. The rule configuration shows it operates release from Knightville, with the rule name 'field at Huntington - Linear' and function 'Westfield at Huntington Stage, Previous Value'. The limit type is 'Maxi...' and interpolation is 'Li...'. A table shows the release limits for various stages, and a graph plots Release (cfs) against Stage (ft).

Stage (ft)	Release (cfs)
0.0	4500.0
7.5	4500.0
8.5	3600.0
9.5	2700.0
10.5	1800.0
11.5	900.0
12.5	0.0
50.0	0.0

Figure 12: Reservoir Editor: Operations Tab – Existing Ops OpSet – Westfield at Huntington-Linear



**8. Max Flow ROC-Increasing**

Figure 14 shows the content of “Max Flow ROC-Increasing” rule. This rule shows the maximum allowable increasing release rate of change as a function of release from Knightville dam.

Operation Set: Existing Ops | Description: [ ]

Zone-Rules: Rel. Alloc. | Outages | Stor. Credit | Dec. Sched. | Projected Elev.

- Surcharge
  - Gate Ops to Save Dam
  - Maximum Release from Controlled Outlets
  - Minimum ABF Release
  - Connecticut at Montague - Linear
  - Connecticut at Hartford - Linear
  - Westfield at Huntington - Linear
  - Downstream control at Westfield
- Flood Control
  - Maximum Release from Controlled Outlets
  - Minimum ABF Release
  - Connecticut at Montague - Linear
  - Connecticut at Hartford - Linear
  - Westfield at Huntington - Linear
  - Downstream control at Westfield
  - Max Flow ROC-Increasing**
  - ABF Maximum rate of decrease
  - { } Restrict rate of pool level drop
  - Max Outflow equals 21 day max Inflow
- Conservation
  - Maximum Release from Controlled Outlets
  - Min Flow Logic - Knightville
  - Connecticut at Montague - Linear
  - Connecticut at Hartford - Linear
  - Westfield at Huntington - Linear
  - Downstream control at Westfield
  - Max Flow ROC-Increasing
  - ABF Maximum rate of decrease
  - { } Restrict rate of pool level drop
- Inactive

Operates Release From: Knightville-Dam at Westfield River

Release Rate of Change Limit: Max Flow ROC-Increasing

Description: [ ]

Function Of: Release

Type: Increasing

Interpolate: Linear

Release (cfs)	Rate Change (cfs/hr)
0.0	500.0
2500.0	500.0
2500.1	250.0
123456.0	250.0

Rate Change (cfs/hr)

Release (cfs)

Figure 14: Reservoir Editor: Operations Tab – Existing Ops OpSet –Max Flow ROC-Increasing

**9. ABF Maximum rate of decrease**

Figure 15 shows the content of “ABF Maximum rate of decrease” rule. This rule shows the maximum allowable decreasing release rate of change.

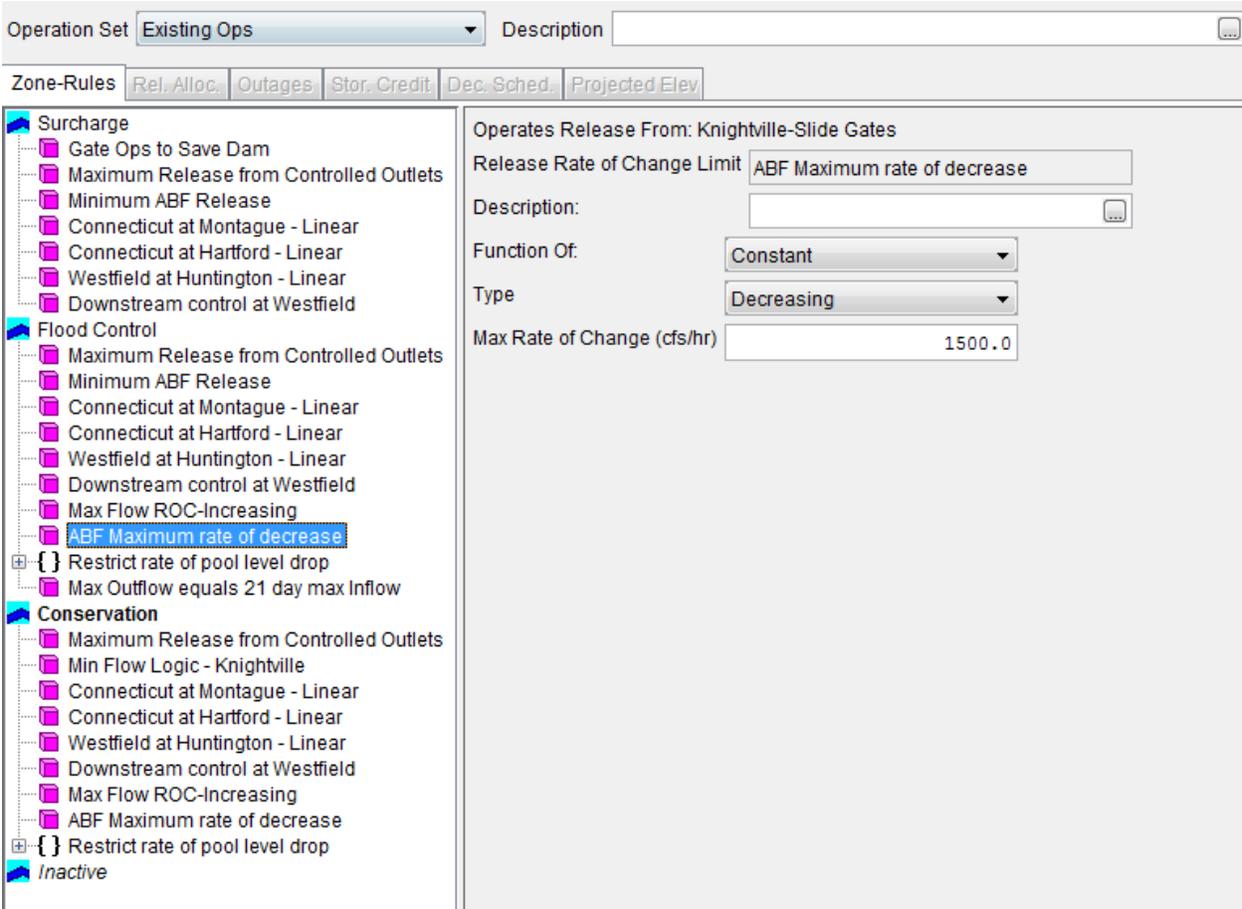


Figure 15: Reservoir Editor: Operations Tab – Existing Ops OpSet –ABF Maximum rate of decrease

**10.Restrict rate of pool level drop**

Figure 16 shows the content of “Restrict rate of pool level drop” rule. It shows the maximum allowable release as a function of Inflow for different ranges of pool elevations.

Operation Set Existing Ops Description

Zone-Rules Rel. Alloc. Outages Stor. Credit Dec. Sched. Projected Elev

**Restrict rate of pool level drop**

- IF (Pool elev >=582 ft)
  - Maximum Release from Controlled Outlets
- ELSE IF (Pool elev >= 576 & <582 ft)
  - Restrict release for pool 576-582
- ELSE IF (Pool elev >=570 & <576 ft)
  - Restrict release for pool 570-576
- ELSE IF (Pool elev >=562.5 & < 570 ft)
  - Restrict release for pool 562.5-570
- ELSE IF (Pool elev >=555 & <562.5)
  - Restrict release for pool 555-562.5
- ELSE IF (Pool elev >= 547.5 & <555)
  - Restrict release for pool 547.5-555
- ELSE IF (Pool elev >= 540 & <547.5 ft)
  - Restrict releases for pool 540-547.5
- ELSE IF (Pool elev >= 532.5 & <540 ft)
  - Restrict releases for pool 532.5-540
- ELSE IF (Pool elev >=525 & <532.5 ft)
  - Restrict releases for pool 525-532.5
- ELSE IF (Pool elev >=520 & <525 ft)
  - Restrict releases for pool 520-525
- ELSE IF (Pool elev >= 515 & <520 ft)
  - Restrict release for pool 515-520
- ELSE IF (Pool elev >=510 & <515)
  - Restrict releases for pool 510-515
- ELSE IF (Pool elev >= 505 & <510 ft)
  - Restrict release for pool 505-510
- ELSE IF (Pool elev >=500 & <505 ft)
  - Restrict release for pool 500-505
- ELSE (Pool elev <500 ft)
  - Restrict release for pool <500 ft

Max Outflow equals 21 day max Inflow

Operates Release From: Knightville-Slide Gates

Name: Restrict rate of pool level drop Description: Prevent pool from dro...

Type	Name	Description
IF	Pool elev >=582 ft	
ELSE IF	Pool elev >= 576 & <582 ft	
ELSE IF	Pool elev >=570 & <576 ft	
ELSE IF	Pool elev >=562.5 & < 570 ft	
ELSE IF	Pool elev >=555 & <562.5	
ELSE IF	Pool elev >= 547.5 & <555	
ELSE IF	Pool elev >= 540 & <547.5 ft	
ELSE IF	Pool elev >= 532.5 & <540 ft	
ELSE IF	Pool elev >=525 & <532.5 ft	
ELSE IF	Pool elev >=520 & <525 ft	
ELSE IF	Pool elev >= 515 & <520 ft	
ELSE IF	Pool elev >=510 & <515	
ELSE IF	Pool elev >= 505 & <510 ft	
ELSE IF	Pool elev >=500 & <505 ft	
ELSE	Pool elev <500 ft	

Operation Set Existing Ops Description

Zone-Rules Rel. Alloc. Outages Stor. Credit Dec. Sched. Projected Elev

Restrict rate of pool level drop

- IF (Pool elev >=582 ft)
  - Maximum Release from Controlled Outlets
- ELSE IF (Pool elev >= 576 & <582 ft)
  - Restrict release for pool 576-582
- ELSE IF (Pool elev >=570 & <576 ft)
  - Restrict release for pool 570-576
- ELSE IF (Pool elev >=562.5 & < 570 ft)
  - Restrict release for pool 562.5-570
- ELSE IF (Pool elev >=555 & <562.5)
  - Restrict release for pool 555-562.5
- ELSE IF (Pool elev >= 547.5 & <555)
  - Restrict release for pool 547.5-555
- ELSE IF (Pool elev >= 540 & <547.5 ft)
  - Restrict releases for pool 540-547.5
- ELSE IF (Pool elev >= 532.5 & <540 ft)
  - Restrict releases for pool 532.5-540
- ELSE IF (Pool elev >=525 & <532.5 ft)
  - Restrict releases for pool 525-532.5
- ELSE IF (Pool elev >=520 & <525 ft)
  - Restrict releases for pool 520-525
- ELSE IF (Pool elev >= 515 & <520 ft)
  - Restrict release for pool 515-520
- ELSE IF (Pool elev >=510 & <515)
  - Restrict releases for pool 510-515
- ELSE IF (Pool elev >= 505 & <510 ft)
  - Restrict release for pool 505-510
- ELSE IF (Pool elev >=500 & <505 ft)
  - Restrict release for pool 500-505
- ELSE (Pool elev <500 ft)
  - Restrict release for pool <500 ft

Operates Release From: Knightville-Slide Gates

Rule Name: t release for pool 576-582 Description:

Function of: Knightville-Pool Inflow, Current Value Define...

Limit Type: Maximum Interp.: Linear

Flow (cfs)	Release (cfs)
0.0	4027.0
473.0	4500.0

Period Average Limit Edit...

Hour of Day Multiplier Edit...

Day of Week Multiplier Edit...

Rising/Falling Condition Edit...

Seasonal Variation Edit...

Operation Set Existing Ops Description

Zone-Rules Rel. Alloc. Outages Stor. Credit Dec. Sched. Projected Elev

Restrict rate of pool level drop

- IF (Pool elev >=582 ft)
  - Maximum Release from Controlled Outlets
- ELSE IF (Pool elev >= 576 & <582 ft)
  - Restrict release for pool 576-582
- ELSE IF (Pool elev >=570 & <576 ft)
  - Restrict release for pool 570-576
- ELSE IF (Pool elev >=562.5 & < 570 ft)
  - Restrict release for pool 562.5-570
- ELSE IF (Pool elev >=555 & <562.5)
  - Restrict release for pool 555-562.5
- ELSE IF (Pool elev >= 547.5 & <555)
  - Restrict release for pool 547.5-555
- ELSE IF (Pool elev >= 540 & <547.5 ft)
  - Restrict releases for pool 540-547.5
- ELSE IF (Pool elev >= 532.5 & <540 ft)
  - Restrict releases for pool 532.5-540
- ELSE IF (Pool elev >=525 & <532.5 ft)
  - Restrict releases for pool 525-532.5
- ELSE IF (Pool elev >=520 & <525 ft)
  - Restrict releases for pool 520-525
- ELSE IF (Pool elev >= 515 & <520 ft)
  - Restrict release for pool 515-520
- ELSE IF (Pool elev >=510 & <515)
  - Restrict releases for pool 510-515
- ELSE IF (Pool elev >= 505 & <510 ft)
  - Restrict release for pool 505-510
- ELSE IF (Pool elev >=500 & <505 ft)
  - Restrict release for pool 500-505
- ELSE (Pool elev <500 ft)
  - Restrict release for pool <500 ft

Operates Release From: Knightville-Slide Gates

Rule Name: t release for pool 570-576 Description:

Function of: Knightville-Pool Inflow, Current Value Define...

Limit Type: Maximum Interp.: Linear

Flow (cfs)	Release (cfs)
0.0	3617.0
883.0	4500.0

Period Average Limit Edit...

Hour of Day Multiplier Edit...

Day of Week Multiplier Edit...

Rising/Falling Condition Edit...

Seasonal Variation Edit...

Operation Set Existing Ops Description

Zone-Rules Rel. Alloc. Outages Stor. Credit Dec. Sched. Projected Elev

Restrict rate of pool level drop

- IF (Pool elev >=582 ft)
  - Maximum Release from Controlled Outlets
- ELSE IF (Pool elev >= 576 & <582 ft)
  - Restrict release for pool 576-582
- ELSE IF (Pool elev >=570 & <576 ft)
  - Restrict release for pool 570-576
- ELSE IF (Pool elev >=562.5 & < 570 ft)
  - Restrict release for pool 562.5-570
- ELSE IF (Pool elev >=555 & <562.5)
  - Restrict release for pool 555-562.5
- ELSE IF (Pool elev >= 547.5 & <555)
  - Restrict release for pool 547.5-555
- ELSE IF (Pool elev >= 540 & <547.5 ft)
  - Restrict releases for pool 540-547.5
- ELSE IF (Pool elev >= 532.5 & <540 ft)
  - Restrict releases for pool 532.5-540
- ELSE IF (Pool elev >=525 & <532.5 ft)
  - Restrict releases for pool 525-532.5
- ELSE IF (Pool elev >=520 & <525 ft)
  - Restrict releases for pool 520-525
- ELSE IF (Pool elev >= 515 & <520 ft)
  - Restrict release for pool 515-520
- ELSE IF (Pool elev >=510 & <515)
  - Restrict releases for pool 510-515
- ELSE IF (Pool elev >= 505 & <510 ft)
  - Restrict release for pool 505-510
- ELSE IF (Pool elev >=500 & <505 ft)
  - Restrict release for pool 500-505
- ELSE (Pool elev <500 ft)
  - Restrict release for pool <500 ft

Operates Release From: Knightville-Slide Gates

Rule Name: release for pool 562.5-570 Description:

Function of: Knightville-Pool Inflow, Current Value Define...

Limit Type: Maximum Interp.: Linear

Flow (cfs)	Release (cfs)
0.0	3118.0
1382.0	4500.0

Period Average Limit Edit...  
 Hour of Day Multiplier Edit...  
 Day of Week Multiplier Edit...  
 Rising/Falling Condition Edit...  
 Seasonal Variation Edit...

Operation Set Existing Ops Description

Zone-Rules Rel. Alloc. Outages Stor. Credit Dec. Sched. Projected Elev

Restrict rate of pool level drop

- IF (Pool elev >=582 ft)
  - Maximum Release from Controlled Outlets
- ELSE IF (Pool elev >= 576 & <582 ft)
  - Restrict release for pool 576-582
- ELSE IF (Pool elev >=570 & <576 ft)
  - Restrict release for pool 570-576
- ELSE IF (Pool elev >=562.5 & < 570 ft)
  - Restrict release for pool 562.5-570
- ELSE IF (Pool elev >=555 & <562.5)
  - Restrict release for pool 555-562.5
- ELSE IF (Pool elev >= 547.5 & <555)
  - Restrict release for pool 547.5-555
- ELSE IF (Pool elev >= 540 & <547.5 ft)
  - Restrict releases for pool 540-547.5
- ELSE IF (Pool elev >= 532.5 & <540 ft)
  - Restrict releases for pool 532.5-540
- ELSE IF (Pool elev >=525 & <532.5 ft)
  - Restrict releases for pool 525-532.5
- ELSE IF (Pool elev >=520 & <525 ft)
  - Restrict releases for pool 520-525
- ELSE IF (Pool elev >= 515 & <520 ft)
  - Restrict release for pool 515-520
- ELSE IF (Pool elev >=510 & <515)
  - Restrict releases for pool 510-515
- ELSE IF (Pool elev >= 505 & <510 ft)
  - Restrict release for pool 505-510
- ELSE IF (Pool elev >=500 & <505 ft)
  - Restrict release for pool 500-505
- ELSE (Pool elev <500 ft)
  - Restrict release for pool <500 ft

Operates Release From: Knightville-Slide Gates

Rule Name: release for pool 555-562.5 Description:

Function of: Knightville-Pool Inflow, Current Value Define...

Limit Type: Maximum Interp.: Linear

Flow (cfs)	Release (cfs)
0.0	2643.0
1857.0	4500.0

Period Average Limit Edit...  
 Hour of Day Multiplier Edit...  
 Day of Week Multiplier Edit...  
 Rising/Falling Condition Edit...  
 Seasonal Variation Edit...

Operation Set Existing Ops Description

Zone-Rules Rel. Alloc. Outages Stor. Credit Dec. Sched. Projected Eley

{ } Restrict rate of pool level drop

- IF (Pool elev >=582 ft)
  - Maximum Release from Controlled Outlets
- ELSE IF (Pool elev >= 576 & <582 ft)
  - Restrict release for pool 576-582
- ELSE IF (Pool elev >=570 & <576 ft)
  - Restrict release for pool 570-576
- ELSE IF (Pool elev >=562.5 & < 570 ft)
  - Restrict release for pool 562.5-570
- ELSE IF (Pool elev >=555 & <562.5)
  - Restrict release for pool 555-562.5
- ELSE IF (Pool elev >= 547.5 & <555)
  - Restrict release for pool 547.5-555
- ELSE IF (Pool elev >= 540 & <547.5 ft)
  - Restrict releases for pool 540-547.5
- ELSE IF (Pool elev >= 532.5 & <540 ft)
  - Restrict releases for pool 532.5-540
- ELSE IF (Pool elev >=525 & <532.5 ft)
  - Restrict releases for pool 525-532.5
- ELSE IF (Pool elev >=520 & <525 ft)
  - Restrict releases for pool 520-525
- ELSE IF (Pool elev >= 515 & <520 ft)
  - Restrict release for pool 515-520
- ELSE IF (Pool elev >=510 & <515)
  - Restrict releases for pool 510-515
- ELSE IF (Pool elev >= 505 & <510 ft)
  - Restrict release for pool 505-510
- ELSE IF (Pool elev >=500 & <505 ft)
  - Restrict release for pool 500-505
- ELSE (Pool elev <500 ft)
  - Restrict release for pool <500 ft

Operates Release From: Knightville-Slide Gates

Rule Name: release for pool 547.5-555 Description:

Function of: Knightville-Pool Inflow, Current Value Define...

Limit Type: Maximum Interp.: Linear

Flow (cfs)	Release (cfs)
0.0	2238.0
2262.0	4500.0

Period Average Limit Edit...

Hour of Day Multiplier Edit...

Day of Week Multiplier Edit...

Rising/Falling Condition Edit...

Seasonal Variation Edit...

Operation Set Existing Ops Description

Zone-Rules Rel. Alloc. Outages Stor. Credit Dec. Sched. Projected Eley

{ } Restrict rate of pool level drop

- IF (Pool elev >=582 ft)
  - Maximum Release from Controlled Outlets
- ELSE IF (Pool elev >= 576 & <582 ft)
  - Restrict release for pool 576-582
- ELSE IF (Pool elev >=570 & <576 ft)
  - Restrict release for pool 570-576
- ELSE IF (Pool elev >=562.5 & < 570 ft)
  - Restrict release for pool 562.5-570
- ELSE IF (Pool elev >=555 & <562.5)
  - Restrict release for pool 555-562.5
- ELSE IF (Pool elev >= 547.5 & <555)
  - Restrict release for pool 547.5-555
- ELSE IF (Pool elev >= 540 & <547.5 ft)
  - Restrict releases for pool 540-547.5
- ELSE IF (Pool elev >= 532.5 & <540 ft)
  - Restrict releases for pool 532.5-540
- ELSE IF (Pool elev >=525 & <532.5 ft)
  - Restrict releases for pool 525-532.5
- ELSE IF (Pool elev >=520 & <525 ft)
  - Restrict releases for pool 520-525
- ELSE IF (Pool elev >= 515 & <520 ft)
  - Restrict release for pool 515-520
- ELSE IF (Pool elev >=510 & <515)
  - Restrict releases for pool 510-515
- ELSE IF (Pool elev >= 505 & <510 ft)
  - Restrict release for pool 505-510
- ELSE IF (Pool elev >=500 & <505 ft)
  - Restrict release for pool 500-505
- ELSE (Pool elev <500 ft)
  - Restrict release for pool <500 ft

Operates Release From: Knightville-Slide Gates

Rule Name: releases for pool 540-547.5 Description:

Function of: Knightville-Pool Inflow, Current Value Define...

Limit Type: Maximum Interp.: Linear

Flow (cfs)	Release (cfs)
0.0	1822.0
2678.0	4500.0

Period Average Limit Edit...

Hour of Day Multiplier Edit...

Day of Week Multiplier Edit...

Rising/Falling Condition Edit...

Seasonal Variation Edit...

Operation Set Existing Ops Description

Zone-Rules Rel. Alloc. Outages Stor. Credit Dec. Sched. Projected Elev

Restrict rate of pool level drop

- IF (Pool elev >=582 ft)
  - Maximum Release from Controlled Outlets
- ELSE IF (Pool elev >= 576 & <582 ft)
  - Restrict release for pool 576-582
- ELSE IF (Pool elev >=570 & <576 ft)
  - Restrict release for pool 570-576
- ELSE IF (Pool elev >=562.5 & < 570 ft)
  - Restrict release for pool 562.5-570
- ELSE IF (Pool elev >=555 & <562.5)
  - Restrict release for pool 555-562.5
- ELSE IF (Pool elev >= 547.5 & <555)
  - Restrict release for pool 547.5-555
- ELSE IF (Pool elev >= 540 & <547.5 ft)
  - Restrict releases for pool 540-547.5
- ELSE IF (Pool elev >= 532.5 & <540 ft)
  - Restrict releases for pool 532.5-540
- ELSE IF (Pool elev >=525 & <532.5 ft)
  - Restrict releases for pool 525-532.5
- ELSE IF (Pool elev >=520 & <525 ft)
  - Restrict releases for pool 520-525
- ELSE IF (Pool elev >= 515 & <520 ft)
  - Restrict release for pool 515-520
- ELSE IF (Pool elev >=510 & <515)
  - Restrict releases for pool 510-515
- ELSE IF (Pool elev >= 505 & <510 ft)
  - Restrict release for pool 505-510
- ELSE IF (Pool elev >=500 & <505 ft)
  - Restrict release for pool 500-505
- ELSE (Pool elev <500 ft)
  - Restrict release for pool <500 ft

Operates Release From: Knightville-Slide Gates

Rule Name: Releases for pool 532.5-540 Description:

Function of: Knightville-Pool Inflow, Current Value Define...

Limit Type: Maximum Interp.: Linear

Flow (cfs)	Release (cfs)
0.0	1400.0
3100.0	4500.0

Period Average Limit Edit...

Hour of Day Multiplier Edit...

Day of Week Multiplier Edit...

Rising/Falling Condition Edit...

Seasonal Variation Edit...

Operation Set Existing Ops Description

Zone-Rules Rel. Alloc. Outages Stor. Credit Dec. Sched. Projected Elev

Restrict rate of pool level drop

- IF (Pool elev >=582 ft)
  - Maximum Release from Controlled Outlets
- ELSE IF (Pool elev >= 576 & <582 ft)
  - Restrict release for pool 576-582
- ELSE IF (Pool elev >=570 & <576 ft)
  - Restrict release for pool 570-576
- ELSE IF (Pool elev >=562.5 & < 570 ft)
  - Restrict release for pool 562.5-570
- ELSE IF (Pool elev >=555 & <562.5)
  - Restrict release for pool 555-562.5
- ELSE IF (Pool elev >= 547.5 & <555)
  - Restrict release for pool 547.5-555
- ELSE IF (Pool elev >= 540 & <547.5 ft)
  - Restrict releases for pool 540-547.5
- ELSE IF (Pool elev >= 532.5 & <540 ft)
  - Restrict releases for pool 532.5-540
- ELSE IF (Pool elev >=525 & <532.5 ft)
  - Restrict releases for pool 525-532.5
- ELSE IF (Pool elev >=520 & <525 ft)
  - Restrict releases for pool 520-525
- ELSE IF (Pool elev >= 515 & <520 ft)
  - Restrict release for pool 515-520
- ELSE IF (Pool elev >=510 & <515)
  - Restrict releases for pool 510-515
- ELSE IF (Pool elev >= 505 & <510 ft)
  - Restrict release for pool 505-510
- ELSE IF (Pool elev >=500 & <505 ft)
  - Restrict release for pool 500-505
- ELSE (Pool elev <500 ft)
  - Restrict release for pool <500 ft

Operates Release From: Knightville-Slide Gates

Rule Name: Releases for pool 525-532.5 Description:

Function of: Knightville-Pool Inflow, Current Value Define...

Limit Type: Maximum Interp.: Linear

Flow (cfs)	Release (cfs)
0.0	999.0
3501.0	4500.0

Period Average Limit Edit...

Hour of Day Multiplier Edit...

Day of Week Multiplier Edit...

Rising/Falling Condition Edit...

Seasonal Variation Edit...

Operation Set Existing Ops Description

Zone-Rules Rel. Alloc. Outages Stor. Credit Dec. Sched. Projected Eley

Restrict rate of pool level drop

- IF (Pool elev >=582 ft)
  - Maximum Release from Controlled Outlets
- ELSE IF (Pool elev >= 576 & <582 ft)
  - Restrict release for pool 576-582
- ELSE IF (Pool elev >=570 & <576 ft)
  - Restrict release for pool 570-576
- ELSE IF (Pool elev >=562.5 & < 570 ft)
  - Restrict release for pool 562.5-570
- ELSE IF (Pool elev >=555 & <562.5)
  - Restrict release for pool 555-562.5
- ELSE IF (Pool elev >= 547.5 & <555)
  - Restrict release for pool 547.5-555
- ELSE IF (Pool elev >= 540 & <547.5 ft)
  - Restrict releases for pool 540-547.5
- ELSE IF (Pool elev >= 532.5 & <540 ft)
  - Restrict releases for pool 532.5-540
- ELSE IF (Pool elev >=525 & <532.5 ft)
  - Restrict releases for pool 525-532.5
- ELSE IF (Pool elev >=520 & <525 ft)
  - Restrict releases for pool 520-525
- Restrict releases for pool 520-525**
- ELSE IF (Pool elev >= 515 & <520 ft)
  - Restrict release for pool 515-520
- ELSE IF (Pool elev >=510 & <515)
  - Restrict releases for pool 510-515
- ELSE IF (Pool elev >= 505 & <510 ft)
  - Restrict release for pool 505-510
- ELSE IF (Pool elev >=500 & <505 ft)
  - Restrict release for pool 500-505
- ELSE (Pool elev <500 ft)
  - Restrict release for pool <500 ft

Operates Release From: Knightville-Slide Gates

Rule Name: releases for pool 520-525 Description:

Function of: Knightville-Pool Inflow, Current Value Define...

Limit Type: Maximum Interp.: Linear

Flow (cfs)	Release (cfs)
0.0	727.0
3773.0	4500.0

Period Average Limit Edit...  
 Hour of Day Multiplier Edit...  
 Day of Week Multiplier Edit...  
 Rising/Falling Condition Edit...  
 Seasonal Variation Edit...

Operation Set Existing Ops Description

Zone-Rules Rel. Alloc. Outages Stor. Credit Dec. Sched. Projected Eley

Restrict rate of pool level drop

- IF (Pool elev >=582 ft)
  - Maximum Release from Controlled Outlets
- ELSE IF (Pool elev >= 576 & <582 ft)
  - Restrict release for pool 576-582
- ELSE IF (Pool elev >=570 & <576 ft)
  - Restrict release for pool 570-576
- ELSE IF (Pool elev >=562.5 & < 570 ft)
  - Restrict release for pool 562.5-570
- ELSE IF (Pool elev >=555 & <562.5)
  - Restrict release for pool 555-562.5
- ELSE IF (Pool elev >= 547.5 & <555)
  - Restrict release for pool 547.5-555
- ELSE IF (Pool elev >= 540 & <547.5 ft)
  - Restrict releases for pool 540-547.5
- ELSE IF (Pool elev >= 532.5 & <540 ft)
  - Restrict releases for pool 532.5-540
- ELSE IF (Pool elev >=525 & <532.5 ft)
  - Restrict releases for pool 525-532.5
- ELSE IF (Pool elev >=520 & <525 ft)
  - Restrict releases for pool 520-525
- ELSE IF (Pool elev >= 515 & <520 ft)
  - Restrict releases for pool 515-520
- Restrict release for pool 515-520**
- ELSE IF (Pool elev >=510 & <515)
  - Restrict releases for pool 510-515
- ELSE IF (Pool elev >= 505 & <510 ft)
  - Restrict release for pool 505-510
- ELSE IF (Pool elev >=500 & <505 ft)
  - Restrict release for pool 500-505
- ELSE (Pool elev <500 ft)
  - Restrict release for pool <500 ft

Operates Release From: Knightville-Slide Gates

Rule Name: x release for pool 515-520 Description:

Function of: Knightville-Pool Inflow, Current Value Define...

Limit Type: Maximum Interp.: Linear

Flow (cfs)	Release (cfs)
0.0	525.0
3976.0	4500.0

Period Average Limit Edit...  
 Hour of Day Multiplier Edit...  
 Day of Week Multiplier Edit...  
 Rising/Falling Condition Edit...  
 Seasonal Variation Edit...

Operation Set Existing Ops Description

Zone-Rules Rel. Alloc. Outages Stor. Credit Dec. Sched. Projected Eley

- Restrict rate of pool level drop
  - IF (Pool elev >=582 ft)
    - Maximum Release from Controlled Outlets
  - ELSE IF (Pool elev >= 576 & <582 ft)
    - Restrict release for pool 576-582
  - ELSE IF (Pool elev >=570 & <576 ft)
    - Restrict release for pool 570-576
  - ELSE IF (Pool elev >=562.5 & < 570 ft)
    - Restrict release for pool 562.5-570
  - ELSE IF (Pool elev >=555 & <562.5)
    - Restrict release for pool 555-562.5
  - ELSE IF (Pool elev >= 547.5 & <555)
    - Restrict release for pool 547.5-555
  - ELSE IF (Pool elev >= 540 & <547.5 ft)
    - Restrict releases for pool 540-547.5
  - ELSE IF (Pool elev >= 532.5 & <540 ft)
    - Restrict releases for pool 532.5-540
  - ELSE IF (Pool elev >=525 & <532.5 ft)
    - Restrict releases for pool 525-532.5
  - ELSE IF (Pool elev >=520 & <525 ft)
    - Restrict releases for pool 520-525
  - ELSE IF (Pool elev >= 515 & <520 ft)
    - Restrict release for pool 515-520
  - ELSE IF (Pool elev >=510 & <515)
    - Restrict releases for pool 510-515
  - Restrict releases for pool 510-515**
  - ELSE IF (Pool elev >= 505 & <510 ft)
    - Restrict release for pool 505-510
  - ELSE IF (Pool elev >=500 & <505 ft)
    - Restrict release for pool 500-505
  - ELSE (Pool elev <500 ft)
    - Restrict release for pool <500 ft

Operates Release From: Knightville-Slide Gates

Rule Name: releases for pool 510-515 Description:

Function of: Knightville-Pool Inflow, Current Value Define...

Limit Type: Maximum Interp.: Linear

Flow (cfs)	Release (cfs)
0.0	352.0
4148.0	4500.0

Period Average Limit Edit...  
 Hour of Day Multiplier Edit...  
 Day of Week Multiplier Edit...  
 Rising/Falling Condition Edit...  
 Seasonal Variation Edit...

Operation Set Existing Ops Description

Zone-Rules Rel. Alloc. Outages Stor. Credit Dec. Sched. Projected Eley

- Restrict rate of pool level drop
  - IF (Pool elev >=582 ft)
    - Maximum Release from Controlled Outlets
  - ELSE IF (Pool elev >= 576 & <582 ft)
    - Restrict release for pool 576-582
  - ELSE IF (Pool elev >=570 & <576 ft)
    - Restrict release for pool 570-576
  - ELSE IF (Pool elev >=562.5 & < 570 ft)
    - Restrict release for pool 562.5-570
  - ELSE IF (Pool elev >=555 & <562.5)
    - Restrict release for pool 555-562.5
  - ELSE IF (Pool elev >= 547.5 & <555)
    - Restrict release for pool 547.5-555
  - ELSE IF (Pool elev >= 540 & <547.5 ft)
    - Restrict releases for pool 540-547.5
  - ELSE IF (Pool elev >= 532.5 & <540 ft)
    - Restrict releases for pool 532.5-540
  - ELSE IF (Pool elev >=525 & <532.5 ft)
    - Restrict releases for pool 525-532.5
  - ELSE IF (Pool elev >=520 & <525 ft)
    - Restrict releases for pool 520-525
  - ELSE IF (Pool elev >= 515 & <520 ft)
    - Restrict release for pool 515-520
  - ELSE IF (Pool elev >=510 & <515)
    - Restrict releases for pool 510-515
  - Restrict releases for pool 510-515**
  - ELSE IF (Pool elev >= 505 & <510 ft)
    - Restrict release for pool 505-510
  - ELSE IF (Pool elev >=500 & <505 ft)
    - Restrict release for pool 500-505
  - ELSE (Pool elev <500 ft)
    - Restrict release for pool <500 ft

Operates Release From: Knightville-Slide Gates

Rule Name: release for pool 505-510 Description:

Function of: Knightville-Pool Inflow, Current Value Define...

Limit Type: Maximum Interp.: Linear

Flow (cfs)	Release (cfs)
0.0	232.0
4268.0	4500.0

Period Average Limit Edit...  
 Hour of Day Multiplier Edit...  
 Day of Week Multiplier Edit...  
 Rising/Falling Condition Edit...  
 Seasonal Variation Edit...

Operation Set: Existing Ops Description: [ ]

Zone-Rules: Rel. Alloc. Outages Stor. Credit Dec. Sched. Projected Elev.

**Restrict rate of pool level drop**

- IF (Pool elev >=582 ft)
  - Maximum Release from Controlled Outlets
- ELSE IF (Pool elev >= 576 & <582 ft)
  - Restrict release for pool 576-582
- ELSE IF (Pool elev >=570 & <576 ft)
  - Restrict release for pool 570-576
- ELSE IF (Pool elev >=562.5 & < 570 ft)
  - Restrict release for pool 562.5-570
- ELSE IF (Pool elev >=555 & <562.5)
  - Restrict release for pool 555-562.5
- ELSE IF (Pool elev >= 547.5 & <555)
  - Restrict release for pool 547.5-555
- ELSE IF (Pool elev >= 540 & <547.5 ft)
  - Restrict releases for pool 540-547.5
- ELSE IF (Pool elev >= 532.5 & <540 ft)
  - Restrict releases for pool 532.5-540
- ELSE IF (Pool elev >=525 & <532.5 ft)
  - Restrict releases for pool 525-532.5
- ELSE IF (Pool elev >=520 & <525 ft)
  - Restrict releases for pool 520-525
- ELSE IF (Pool elev >= 515 & <520 ft)
  - Restrict release for pool 515-520
- ELSE IF (Pool elev >=510 & <515)
  - Restrict releases for pool 510-515
- ELSE IF (Pool elev >= 505 & <510 ft)
  - Restrict release for pool 505-510
- ELSE IF (Pool elev >=500 & <505 ft)
  - Restrict release for pool 500-505
- ELSE (Pool elev <500 ft)
  - Restrict release for pool <500 ft

Operates Release From: Knightville-Slide Gates

Rule Name: t release for pool 500-505 Description: [ ]

Function of: Knightville-Pool Inflow, Current Value Define...

Limit Type: Maximum Interp.: Linear

Flow (cfs)	Release (cfs)
0.0	130.0
4350.0	4500.0

Period Average Limit Edit...  
 Hour of Day Multiplier Edit...  
 Day of Week Multiplier Edit...  
 Rising/Falling Condition Edit...  
 Seasonal Variation Edit...

---

Operation Set: Existing Ops Description: [ ]

Zone-Rules: Rel. Alloc. Outages Stor. Credit Dec. Sched. Projected Elev.

**Restrict rate of pool level drop**

- IF (Pool elev >=582 ft)
  - Maximum Release from Controlled Outlets
- ELSE IF (Pool elev >= 576 & <582 ft)
  - Restrict release for pool 576-582
- ELSE IF (Pool elev >=570 & <576 ft)
  - Restrict release for pool 570-576
- ELSE IF (Pool elev >=562.5 & < 570 ft)
  - Restrict release for pool 562.5-570
- ELSE IF (Pool elev >=555 & <562.5)
  - Restrict release for pool 555-562.5
- ELSE IF (Pool elev >= 547.5 & <555)
  - Restrict release for pool 547.5-555
- ELSE IF (Pool elev >= 540 & <547.5 ft)
  - Restrict releases for pool 540-547.5
- ELSE IF (Pool elev >= 532.5 & <540 ft)
  - Restrict releases for pool 532.5-540
- ELSE IF (Pool elev >=525 & <532.5 ft)
  - Restrict releases for pool 525-532.5
- ELSE IF (Pool elev >=520 & <525 ft)
  - Restrict releases for pool 520-525
- ELSE IF (Pool elev >= 515 & <520 ft)
  - Restrict release for pool 515-520
- ELSE IF (Pool elev >=510 & <515)
  - Restrict releases for pool 510-515
- ELSE IF (Pool elev >= 505 & <510 ft)
  - Restrict release for pool 505-510
- ELSE IF (Pool elev >=500 & <505 ft)
  - Restrict release for pool 500-505
- ELSE (Pool elev <500 ft)
  - Restrict release for pool <500 ft

Operates Release From: Knightville-Slide Gates

Rule Name: tict release for pool <500 ft Description: [ ]

Function of: Knightville-Pool Inflow, Current Value Define...

Limit Type: Maximum Interp.: Linear

Flow (cfs)	Release (cfs)
0.0	88.0
4412.0	4500.0

Period Average Limit Edit...  
 Hour of Day Multiplier Edit...  
 Day of Week Multiplier Edit...  
 Rising/Falling Condition Edit...  
 Seasonal Variation Edit...

Figure 16: Reservoir Editor: Operations Tab – Existing Ops OpSet – Restrict rate of pool level drop

**11. Max Outflow equals 21 day max Inflow**

Figure 17 shows the content of “Max Outflow equals 21 day max Inflow” rule. This rule represents the maximum release from dam as a function of the previous 3 weeks of inflow.

The screenshot shows the 'Operations Tab' in the 'Existing Ops' OpSet. The left sidebar lists various rules under categories like Surchage, Flood Control, and Conservation. The 'Max Outflow equals 21 day max Inflow' rule is selected. The main panel displays the rule's configuration:

- Operates Release From: Knightville
- Rule Name: equals 21 day max Inflow
- Function of: -Pool Inflow, Period Maximum, 0.0 hr lag, 504.0 hr period
- Limit Type: Maxi... Interp.: Li...

Flow (cfs)	Release (cfs)
0.0	0.0
4500.0	4500.0
123456.0	4500.0

The graph on the right shows Release (cfs) on the y-axis (0 to 5,000) and Flow (cfs) on the x-axis (0 to 120,000). The plot shows a horizontal line at 4,500 cfs release for flow values greater than 4,500 cfs.

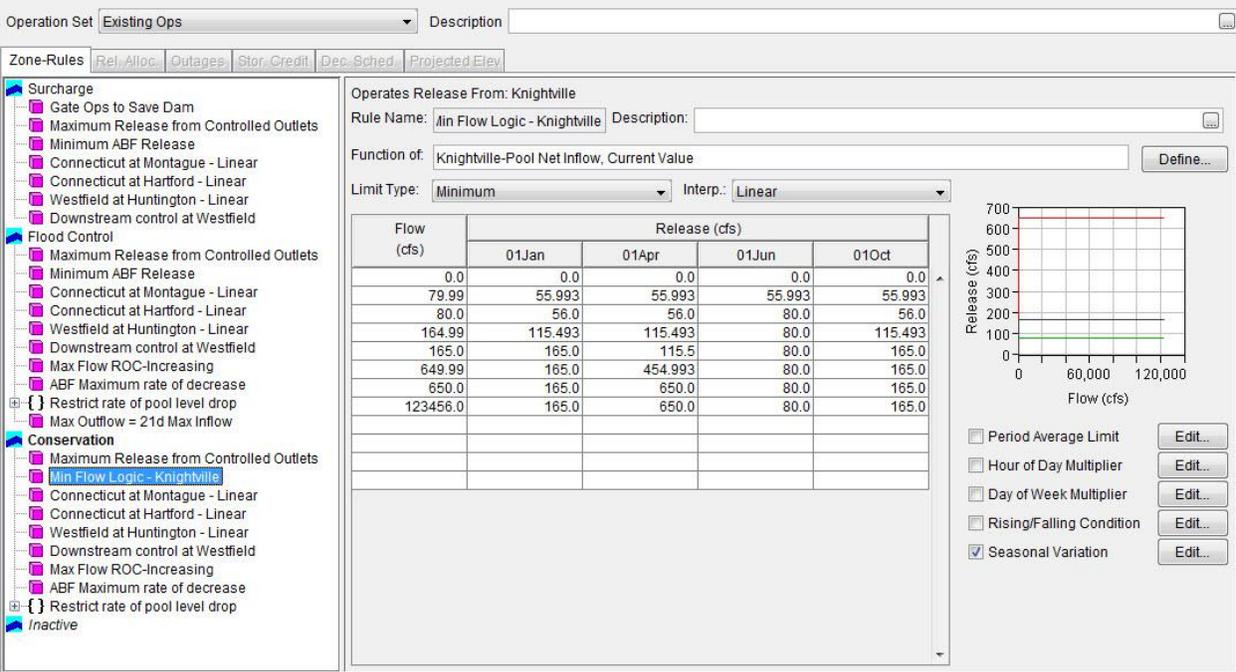
Control options on the right include:

- Period Average Limit
- Hour of Day Multiplier
- Day of Week Multiplier
- Rising/Falling Condition
- Seasonal Variation

Figure 17: Reservoir Editor: Operations Tab – Existing Ops OpSet – Max Outflow equals 21 day max Inflow

**12. Min Flow Logic - Knightsville**

Figure 18 shows the content of “Min Flow Logic - Knightsville” rule. This rule describes required seasonal minimum flows from controlled outlets as a function of inflow at Knightsville.



**Figure 18: Reservoir Editor: Operations Tab – Existing Ops OpSet – Min Flow Logic - Knightsville**

# Lake Francis

## I. Overview

Lake Francis (Murphy) dam is located in the town of Pittsburg, NH. It is owned and operated by TransCanada Hydro Northeast Inc. as a storage reservoir to make releases to its downstream hydro facilities.

Figure 1 shows the location of Lake Francis as it is represented in the HEC-ResSim model. Figure 2 shows a photo of Lake Francis.

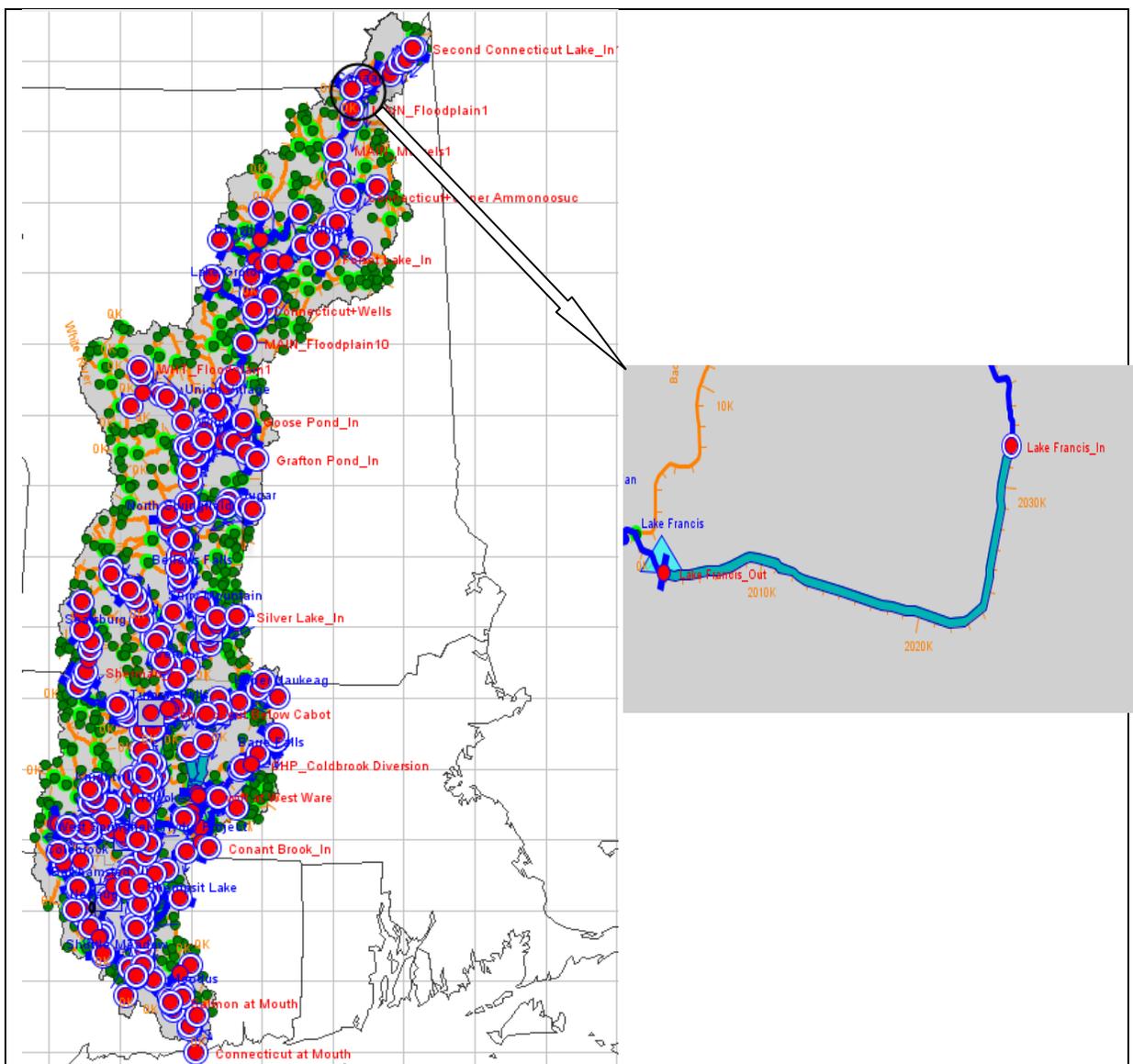


Figure 1: HEC-ResSim Map Display Showing Location of First Connecticut Dam



**Figure 2: Aerial photo of Lake Francis**

## **II. Physical Characteristics**

The physical characteristics of the reservoir are separated between the Pool and the Dam in the HEC-ResSim model. The elevation-storage-area defines the pool as shown in Figure 3<sup>50</sup>. The dam consists of seven types of outlets: (1) uncontrolled Bay#1, (2) uncontrolled Bay#5 (flashboards all in), (3) uncontrolled Bay#5 (flashboards partly cleared), (4) uncontrolled Bay#2, (5) uncontrolled Bay#3, (6) uncontrolled Bay#4, and (7) controlled Tunnel discharge as shown in Figure 4.

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<sup>50</sup> Data provided by TransCanada

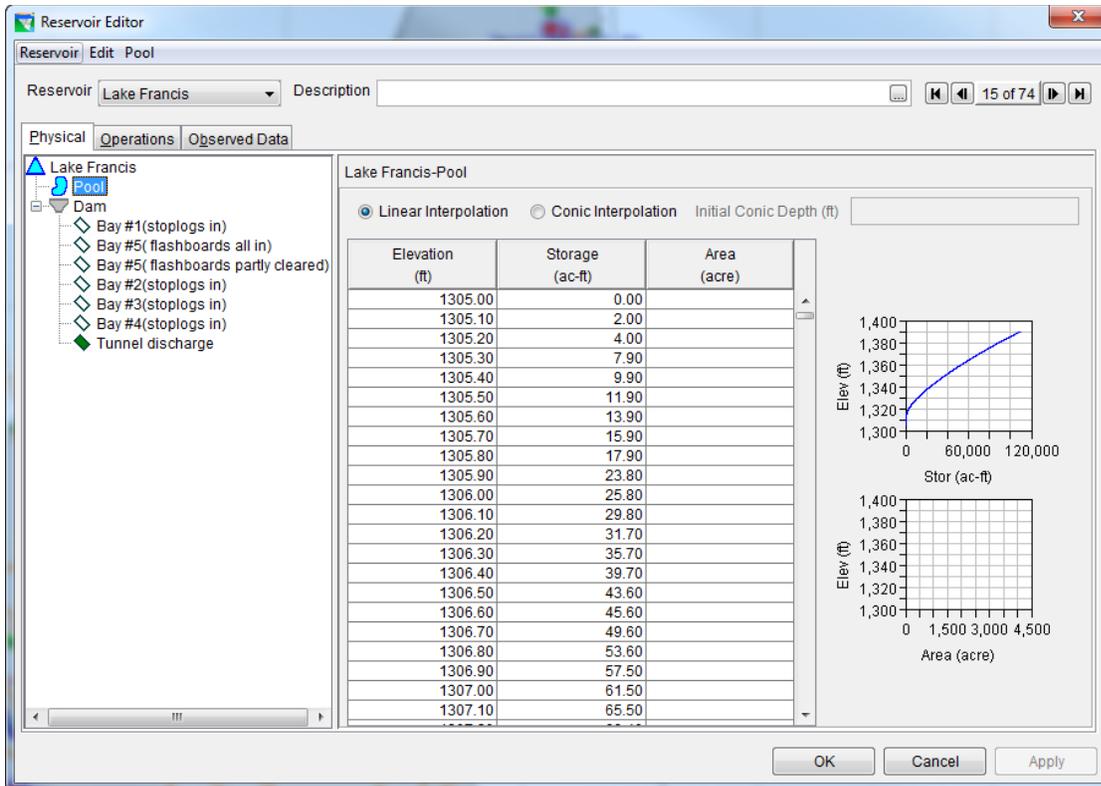


Figure 3: Reservoir Editor: Physical Tab -- Pool

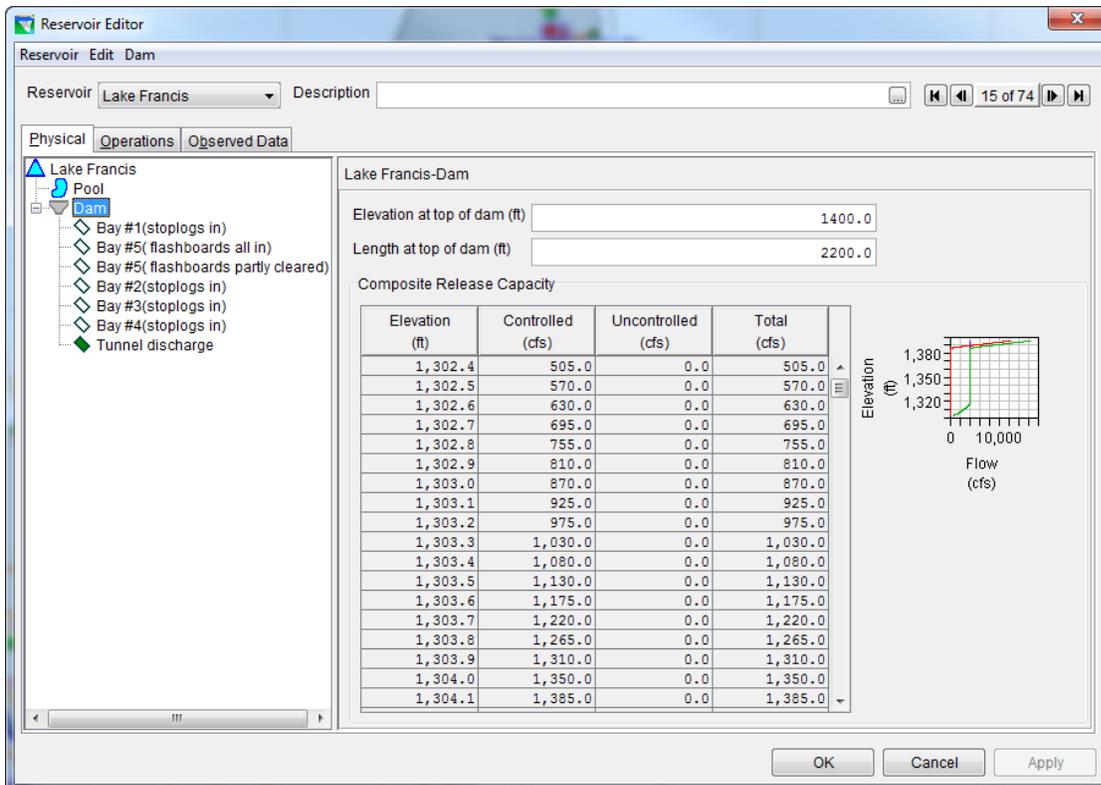


Figure 4: Reservoir Editor: Physical Tab -- Dam

### III. Operations

#### A. Operation Set

Zones are used to define the operational storage in the reservoir to determine the reservoir release through analysis of the rules contained within each zone. Figure 5 shows the definition of First Connecticut Dam’s “Existing Ops” operational zones, which consist of zones of Top of dam (1400 ft), Below Top of dam (1399 ft), Conservation (1340.492-1379.249 ft), and Inactive zone (1305 ft). The Conservation Pool Elevation curve was created from 10 years of weekly average pool elevation<sup>1</sup>.

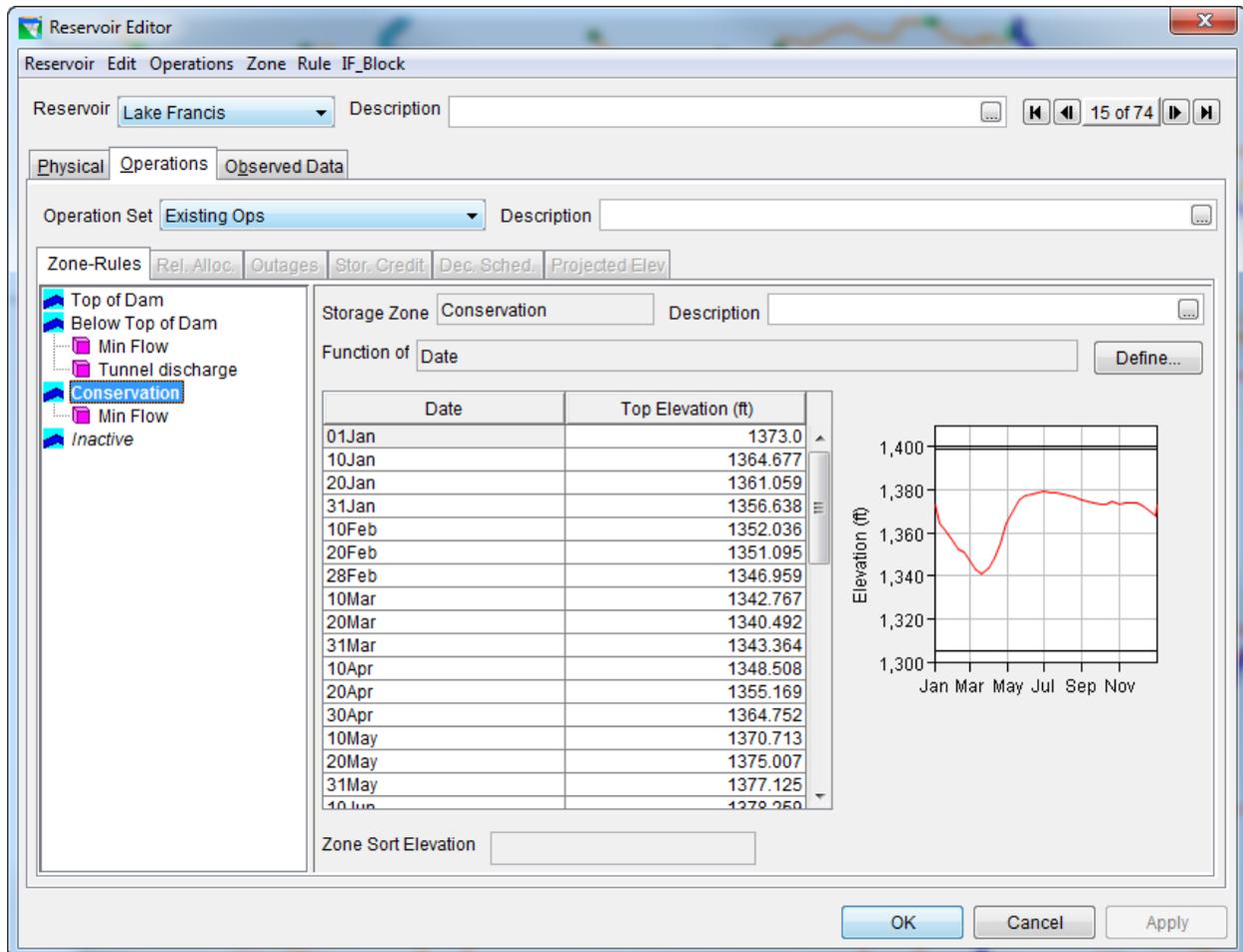


Figure 5: Reservoir Editor: Operations Tab –Existing Ops OpSet – Guide Curve

## B. Rule Illustrations

Figure 6 shows a set of operational rules specified for each zone that reflects the operation set named Existing<sup>51</sup>.

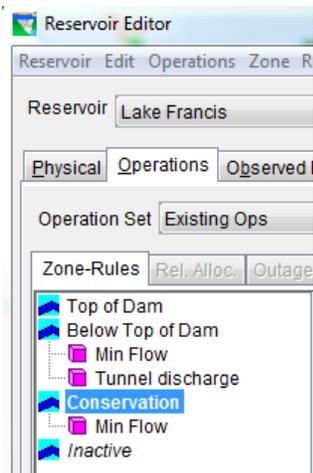


Figure 6: Reservoir Editor: Operations Tab – Existing Ops OpSet – Zones and Rules

## C. Rule Descriptions

### 1. Min Flow

Figure 7 shows the content of “Min Flow” rule. This rule represents the minimum release from dam as a function of date.

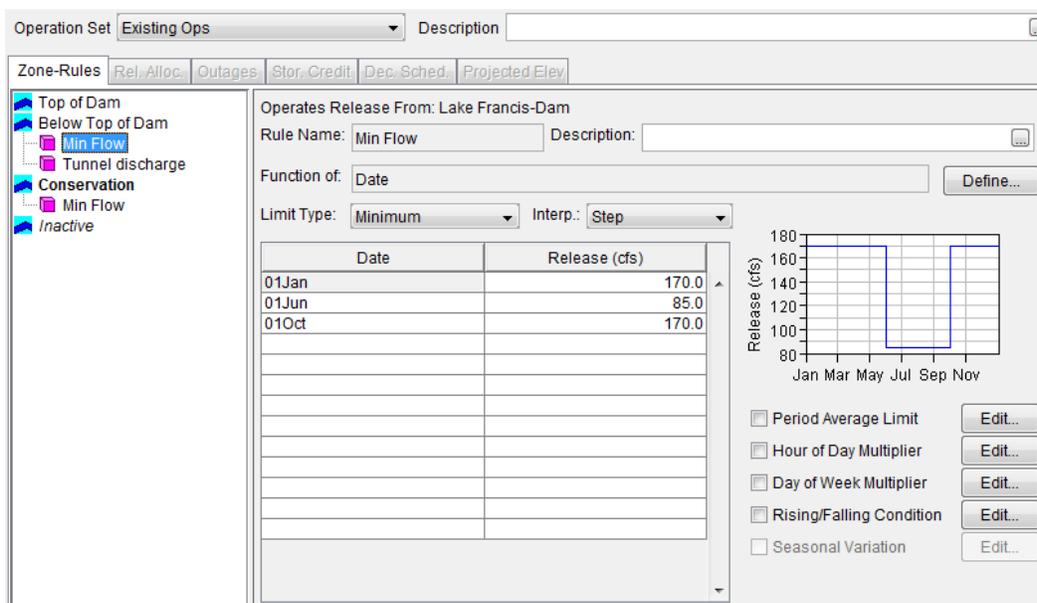


Figure 7: Reservoir Editor: Operations Tab – Existing Ops OpSet – Min Flow

<sup>51</sup> TransCanada. Connecticut River Operational Constraints. 2012.

## 2. Tunnel discharge

Figure 8 shows the content of “Tunnel discharge” rule. This rule represents the maximum release from the Tunnel discharge gate as a function of pool elevation.

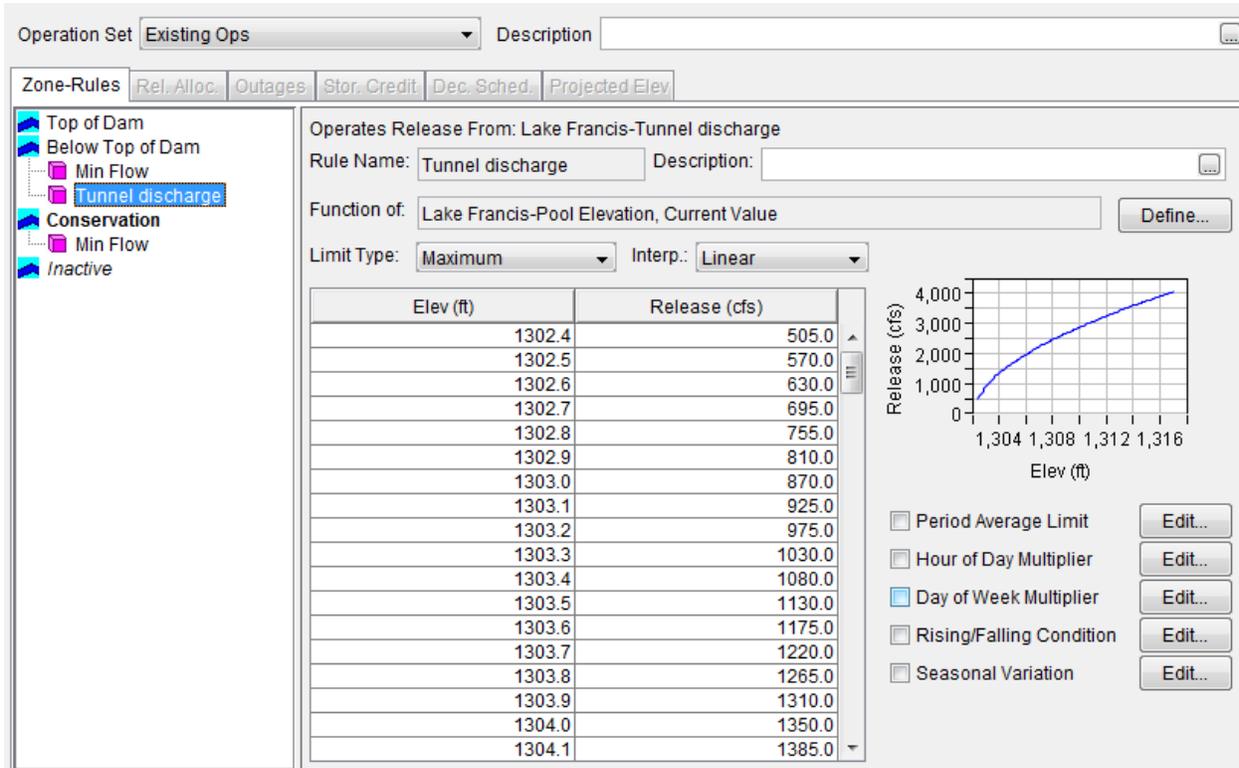


Figure 8: Reservoir Editor: Operations Tab – Existing Ops OpSet – Tunnel discharge

# Lake Groton

## I. Overview

Lake Groton dam is a dam located in Groton, VT at the headwaters of the Wells River. It is owned and operated by the State of Vermont Department of Water Resources and is used primarily for recreational purposes.

Figure 1 shows the location of Lake Groton Dam as it is represented in the HEC-ResSim model, and Figure 2 shows a photo of Lake Groton Dam.

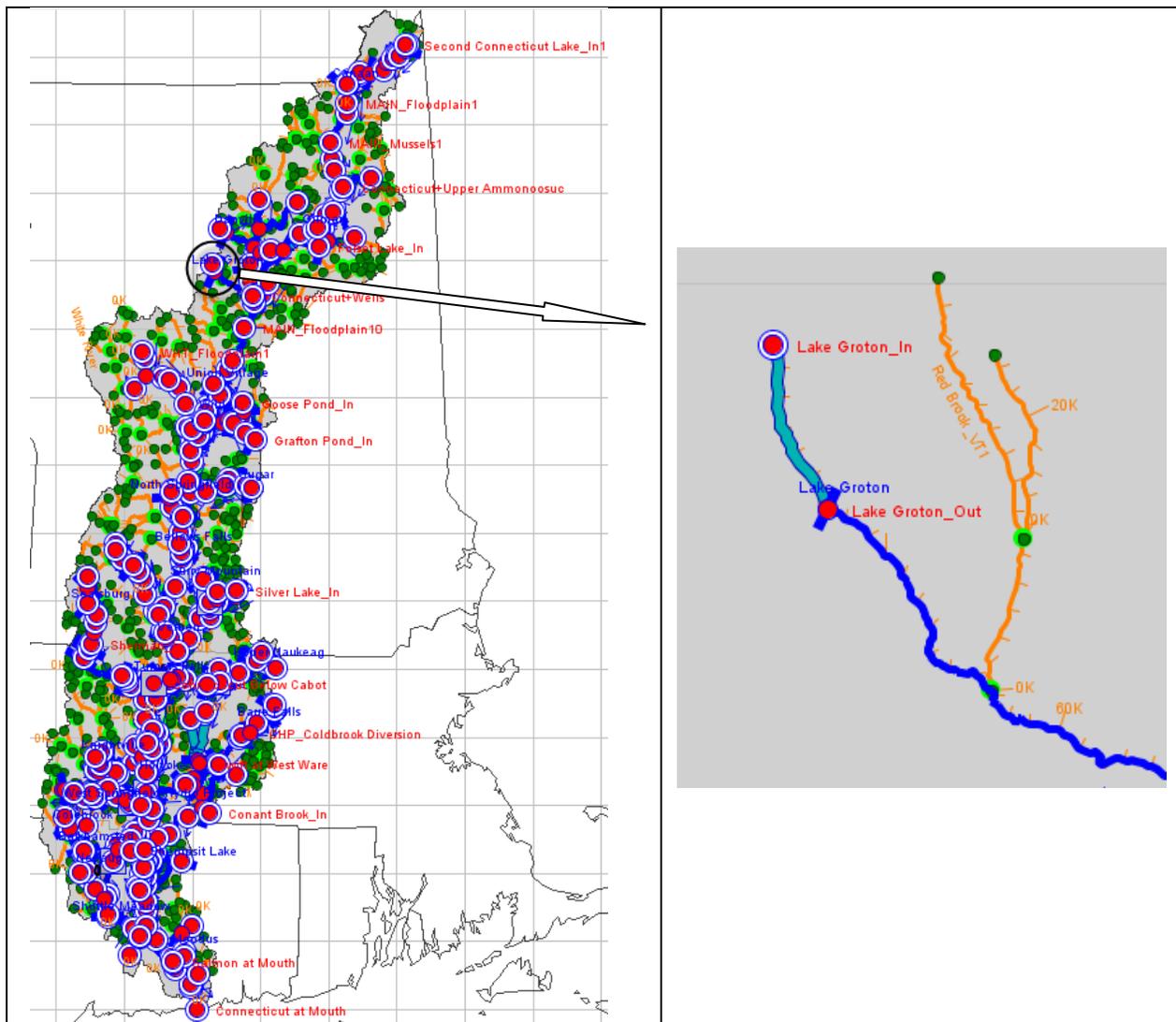


Figure 1: HEC-ResSim Map Display Showing Location of Somerset



**Figure 2: Photo of Lake Groton Dam**

## **II. Physical Characteristics**

The physical characteristics of the reservoir are separated between the Pool and the Dam in the HEC-ResSim model. The elevation-storage-area defines the pool as shown in Figure 3<sup>52</sup>. The dam consists of four types of outlets: (1) uncontrolled spillway, (2) uncontrolled stop log spillway, (3) uncontrolled Core wall+ Embankment, and (4) uncontrolled Island as shown in Figure 4.

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<sup>52</sup> State of Vermont Dam Inventory. 2010.





## B. Rule Illustrations

Figure 6 shows a set of operational rules specified for each zone that reflects the operation set named Guide Curve.



Figure 6: Reservoir Editor: Operations Tab – Existing Ops OpSet – Zones and Rules

## C. Rule Descriptions

### 1. Min release

Figure 7 shows the content of “Min release” rule. This rule represents a seasonal minimum flow as a function of Inflow.

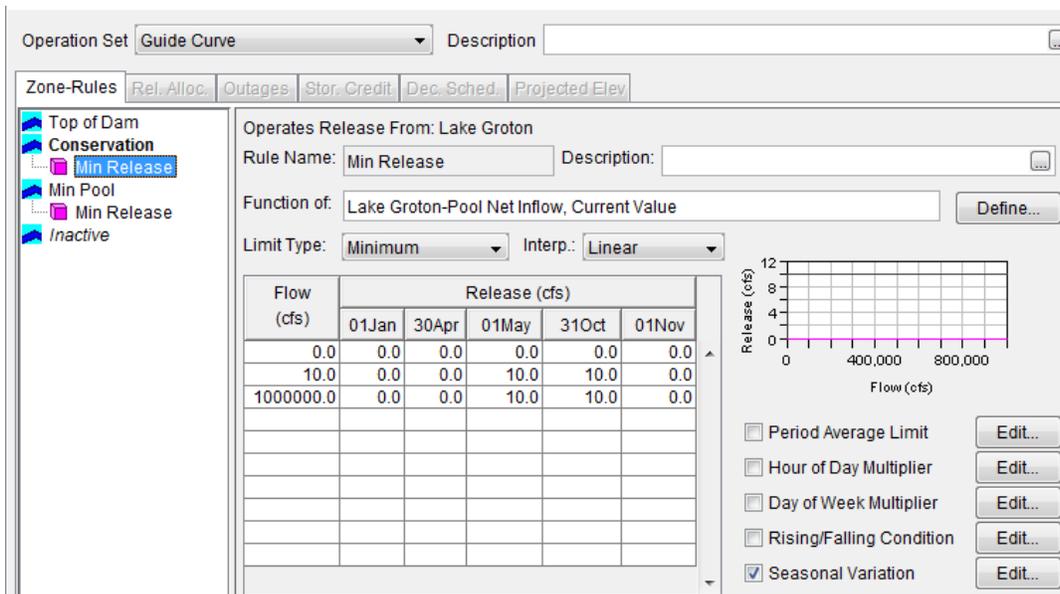


Figure 7: Reservoir Editor: Operations Tab – Guide Curve OpSet – Min Release

## Lake McDonough

### I. Overview

Lake McDonough dam is located directly downstream of Barkhamsted Reservoir that feeds into the Farmington River. It is owned and operated by The Metropolitan District of Hartford, Connecticut (MDC) and is used for recreation.

Figure 1 shows the location of Lake McDonough as it is represented in the HEC-ResSim model, and Figure 2 shows a photo for Lake McDonough.

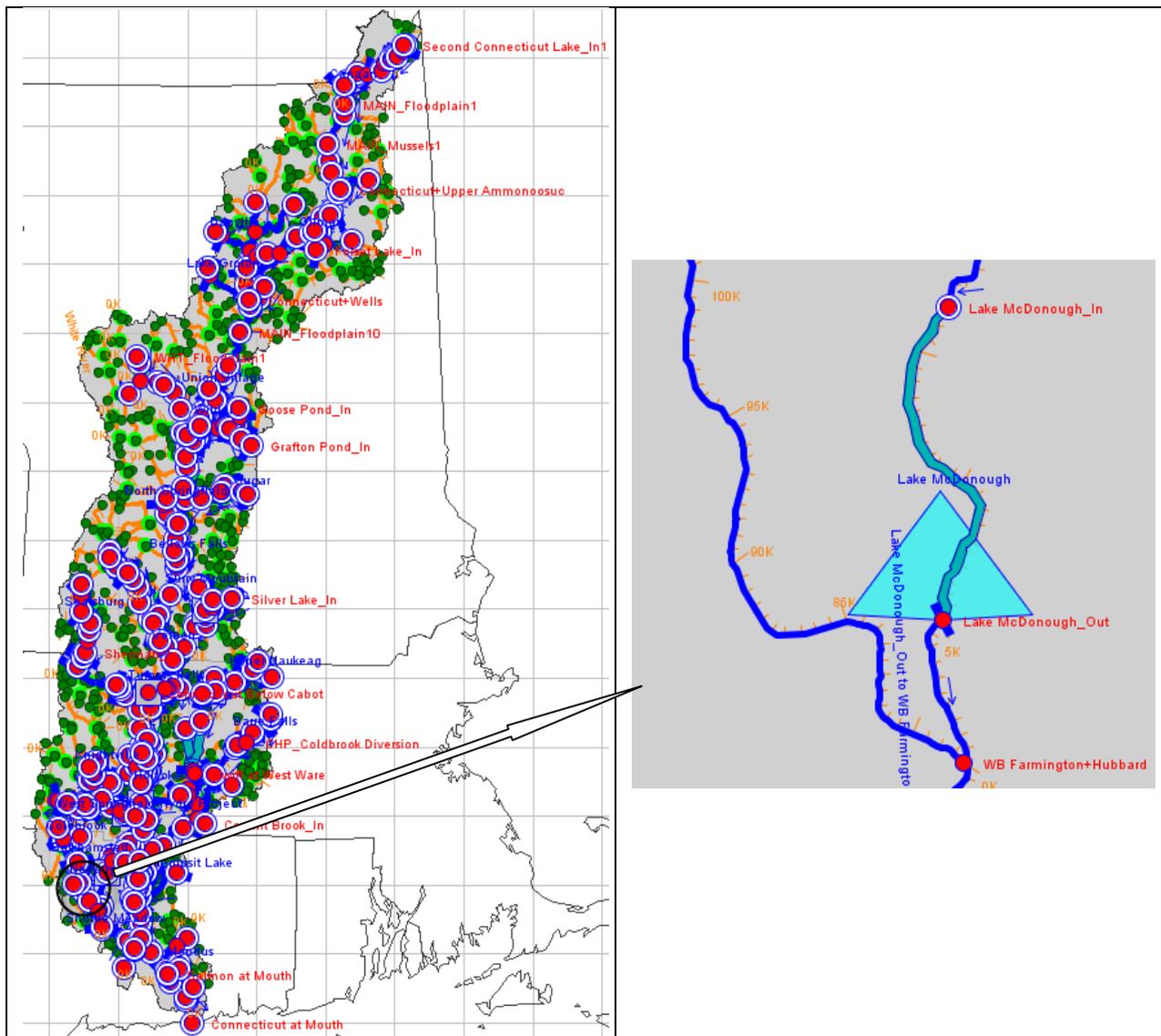


Figure 1: HEC-ResSim Map Display Showing Location of Lake McDonough



Figure 2: Aerial photo of Lake McDonough

## II. Physical Characteristics

The physical characteristics of the reservoir are separated between the Pool and the Dam in the HEC-ResSim model. The elevation-storage-area defines the pool as shown in Figure 3<sup>53</sup>. The dam consists of a controlled outlet as shown in Figure 4<sup>54</sup>.

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<sup>53</sup> MDC 1999

<sup>54</sup> Data from UMASS

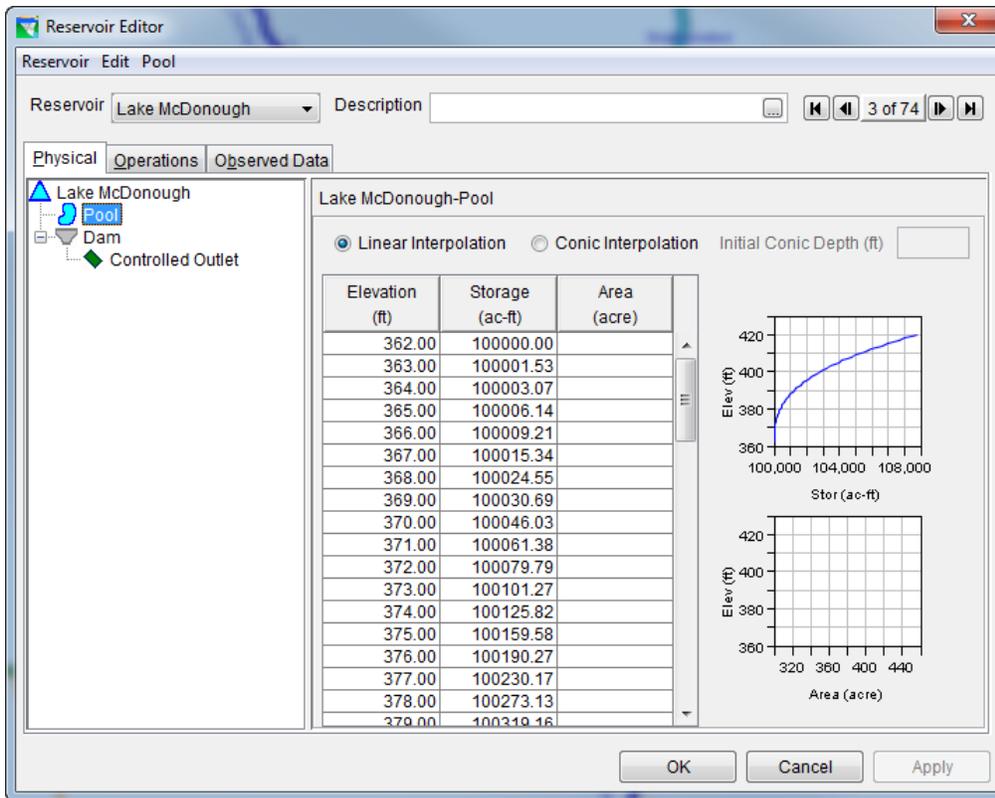


Figure 3: Reservoir Editor: Physical Tab -- Pool

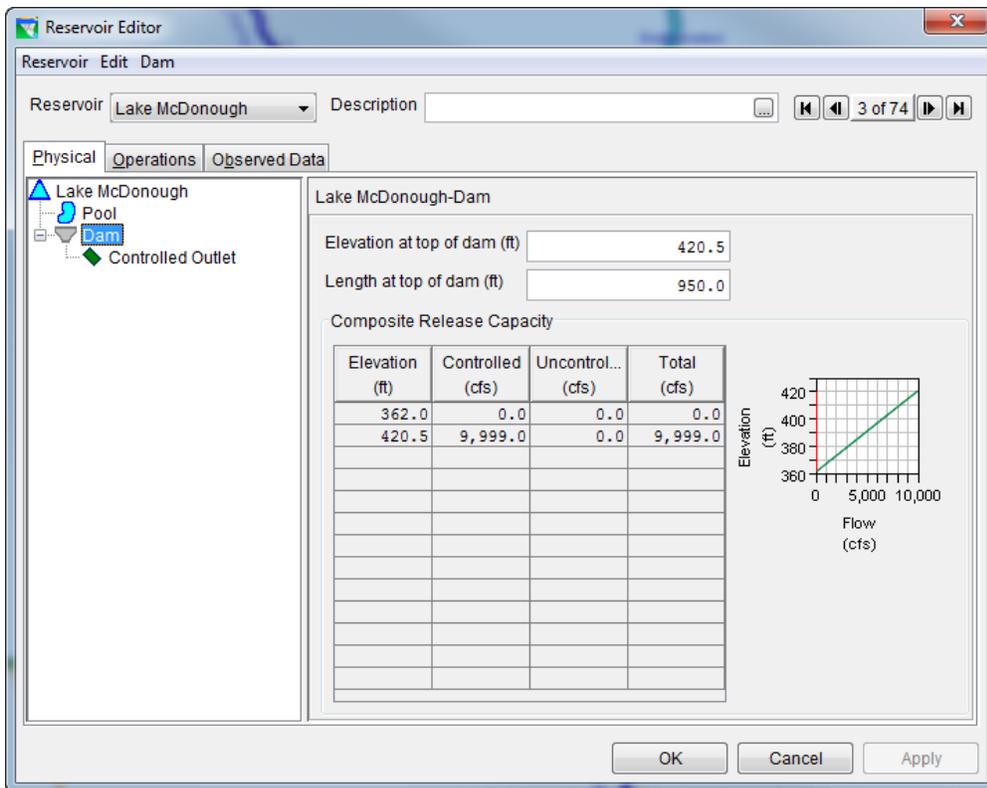


Figure 4: Reservoir Editor: Physical Tab -- Dam

### III. Operations

#### A. Operation Set

Zones are used to define the operational storage in the reservoir to determine the reservoir release through analysis of the rules contained within each zone. Figure 5 shows the definition of Lake McDonough’s “Existing Ops” operational zones, which consist of zones of Top of Dam (420.5 ft), Conservation (410-417.5 ft), and Inactive zone (362 ft)<sup>2</sup>.

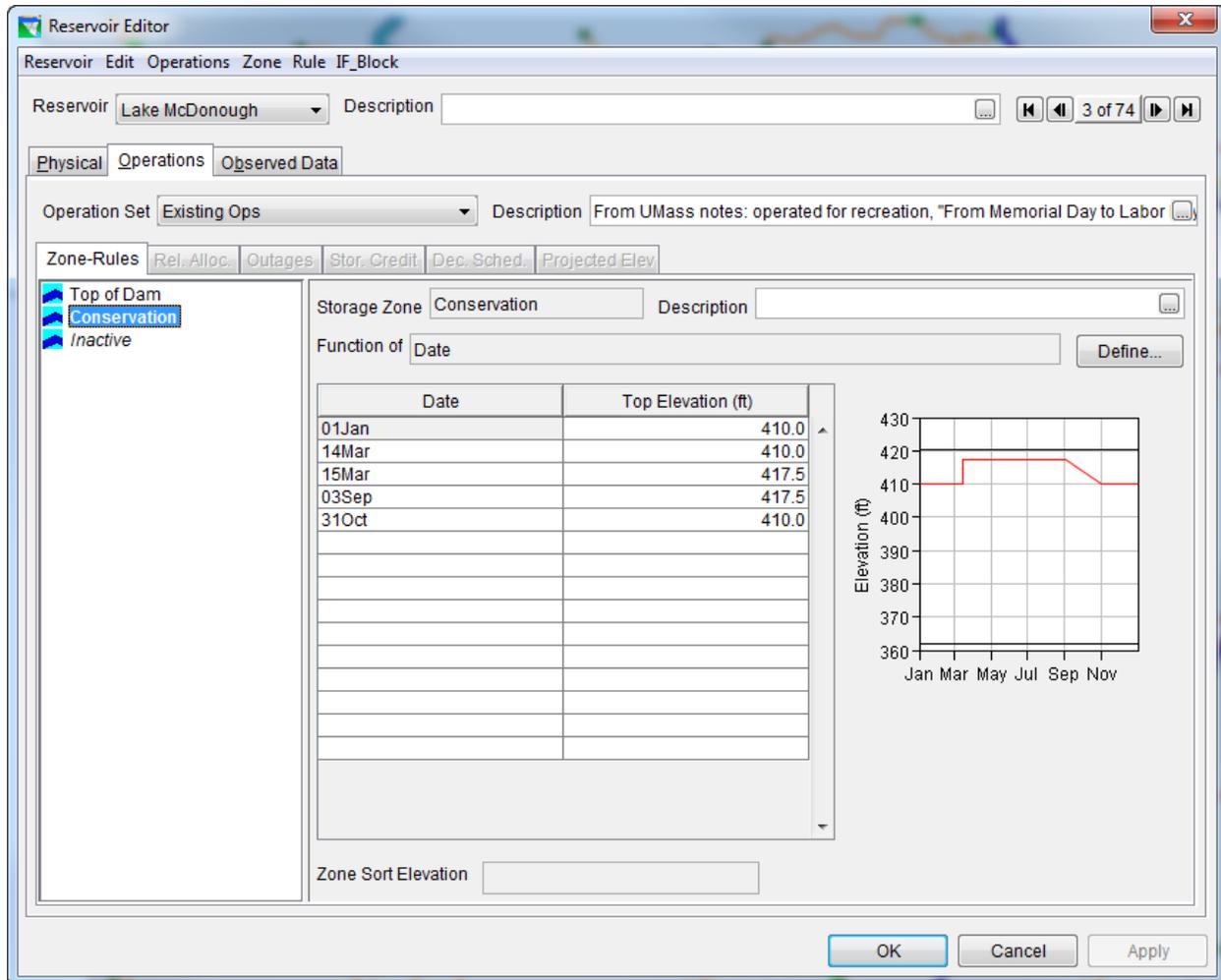


Figure 5: Reservoir Editor: Operations Tab – Existing Ops OpSet

#### B. Rule Illustrations

The operation set for Lake McDonough has no rules of operation making it a flow through reservoir. The pool elevation will remain at the top of conservation unless the inflow exceeds the total release capacity.

# Lake Monomonic

## I. Overview

Lake Monomonic dam is located in the town of Winchendon, MA on the Monomonic River that flows into the Millers River. The Town of Winchendon owns and operates the dam and is used primarily for recreational purposes.

Figure 1 shows the location of Upper Lake Monomonic Dam as it is represented in the HEC-ResSim model. Figure 2 shows a photo of Lake Monomonic.

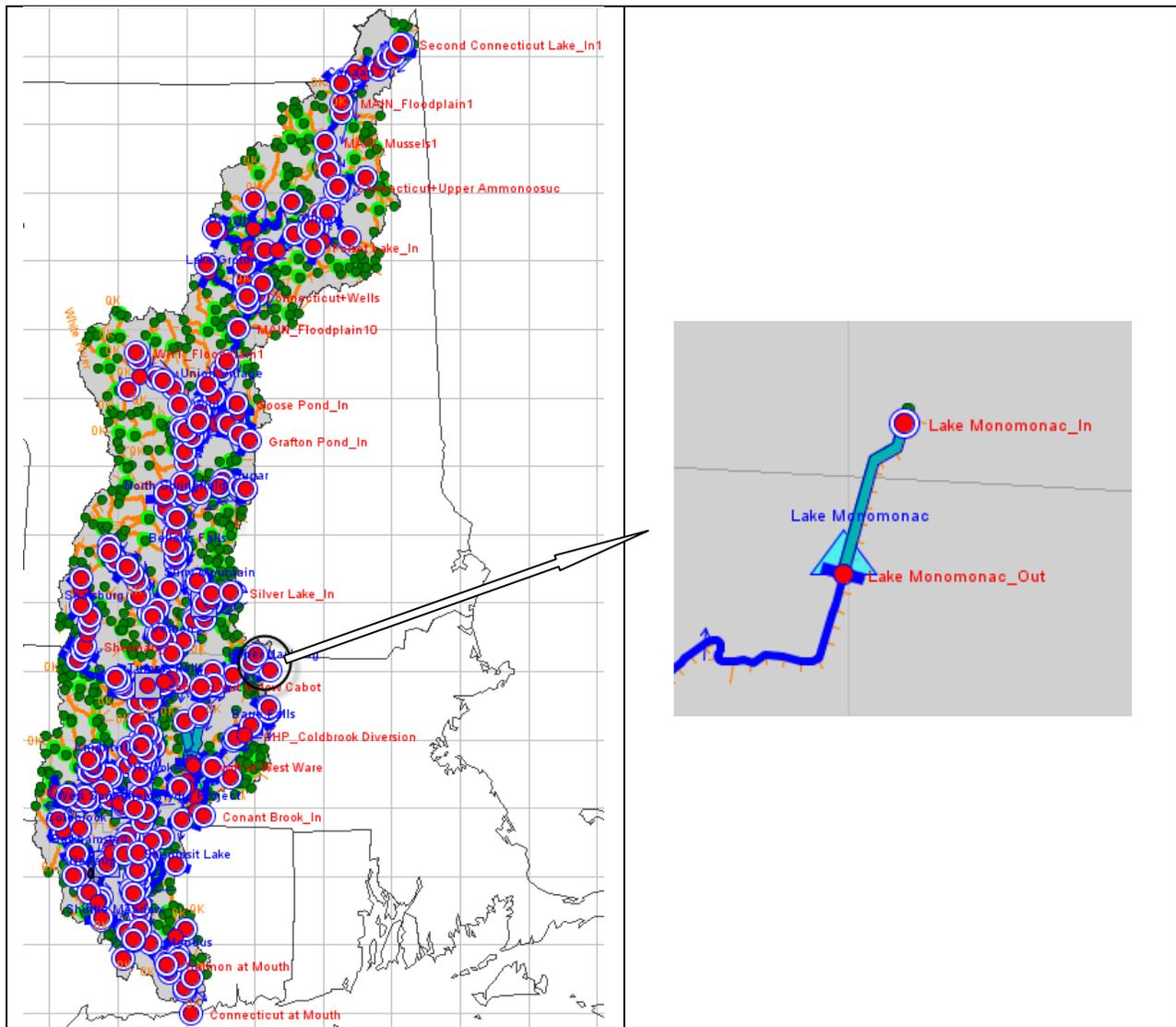


Figure 1: HEC-ResSim Map Display Showing Location of Lake Monomonic Dam



**Figure 2: Photo of Lake Monomonac**

## **II. Physical Characteristics**

The physical characteristics of the reservoir are separated between the Pool and the Dam in the HEC-ResSim model. The elevation-storage-area defines the pool as shown in Figure 3<sup>55</sup>. The dam consists of two types of outlets: (1) an uncontrolled outlet, and (2) a controlled outlet as shown in Figure 4.

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<sup>55</sup> C.T. Male Associates, P.C. Lake Monomonac Dam.



### III. Operations

#### A. Operation Set

Zones are used to define the operational storage in the reservoir to determine the reservoir release through analysis of the rules contained within each zone. Figure 5 shows the definition of Lake Monomonac Dam’s “Guide Curve” operational zones, which consist of zones of Flood Control (1048.3 ft), Conservation (1045-1047 ft), and Inactive zone (1041 ft)<sup>1</sup>.

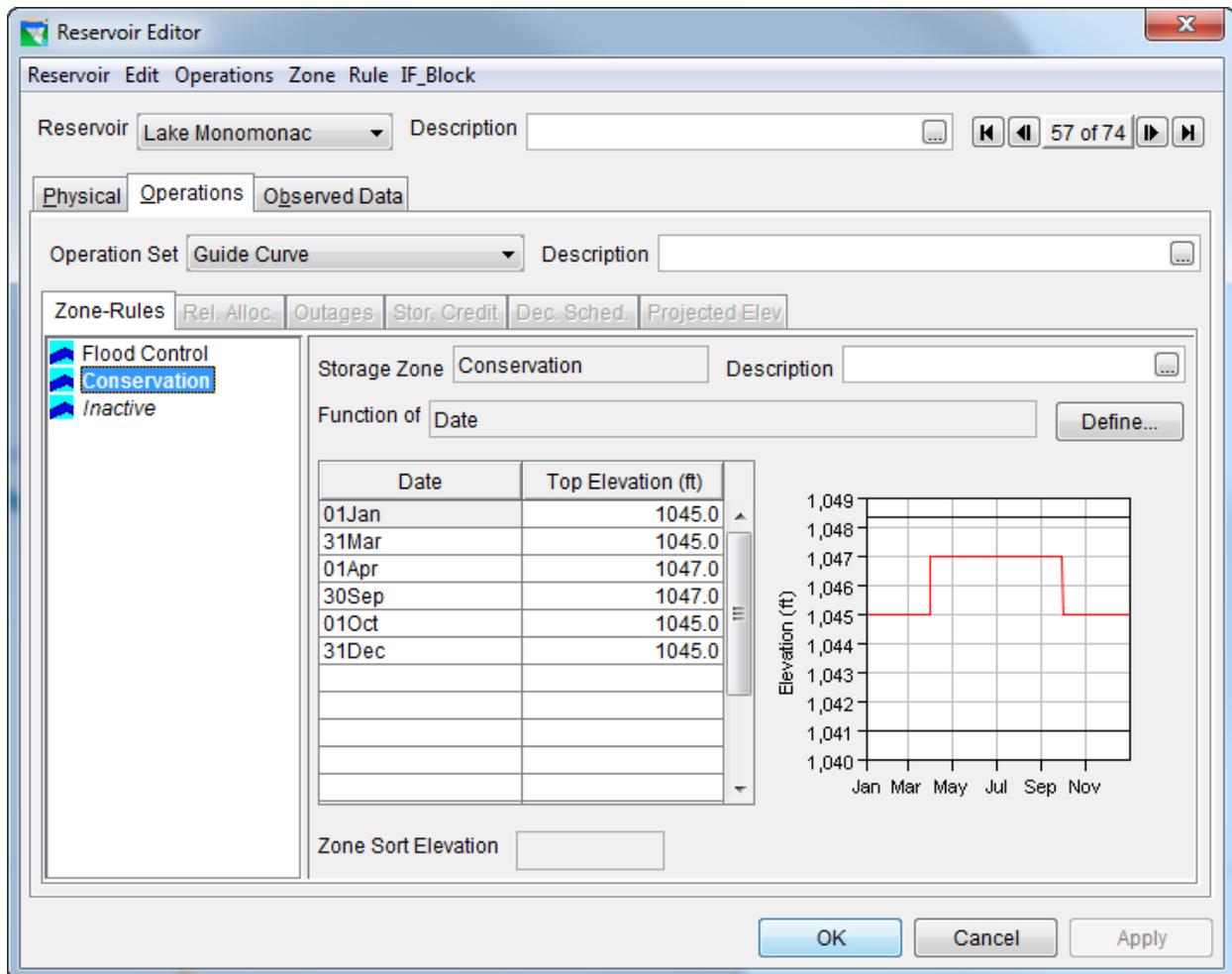


Figure 5: Reservoir Editor: Operations Tab – Guide Curve OpSet

#### B. Rule Illustrations

The operation set for Lake Monomonac Dam has no rules of operation making it a flow through reservoir. The pool elevation will remain at the top of conservation unless the inflow exceeds the total release capacity.

# Lake Sunapee

## I. Overview

Lake Sunapee dam is located in the town of Sunapee, NH on the Sugar River. It is owned and operated by the Town of Sunapee and is used for powering the town's water works pumping station as well as recreational purposes.

Figure 1 shows the location of Lake Sunapee Dam as it is represented in the HEC-ResSim model. Figure 2 shows a photo of Lake Sunapee.

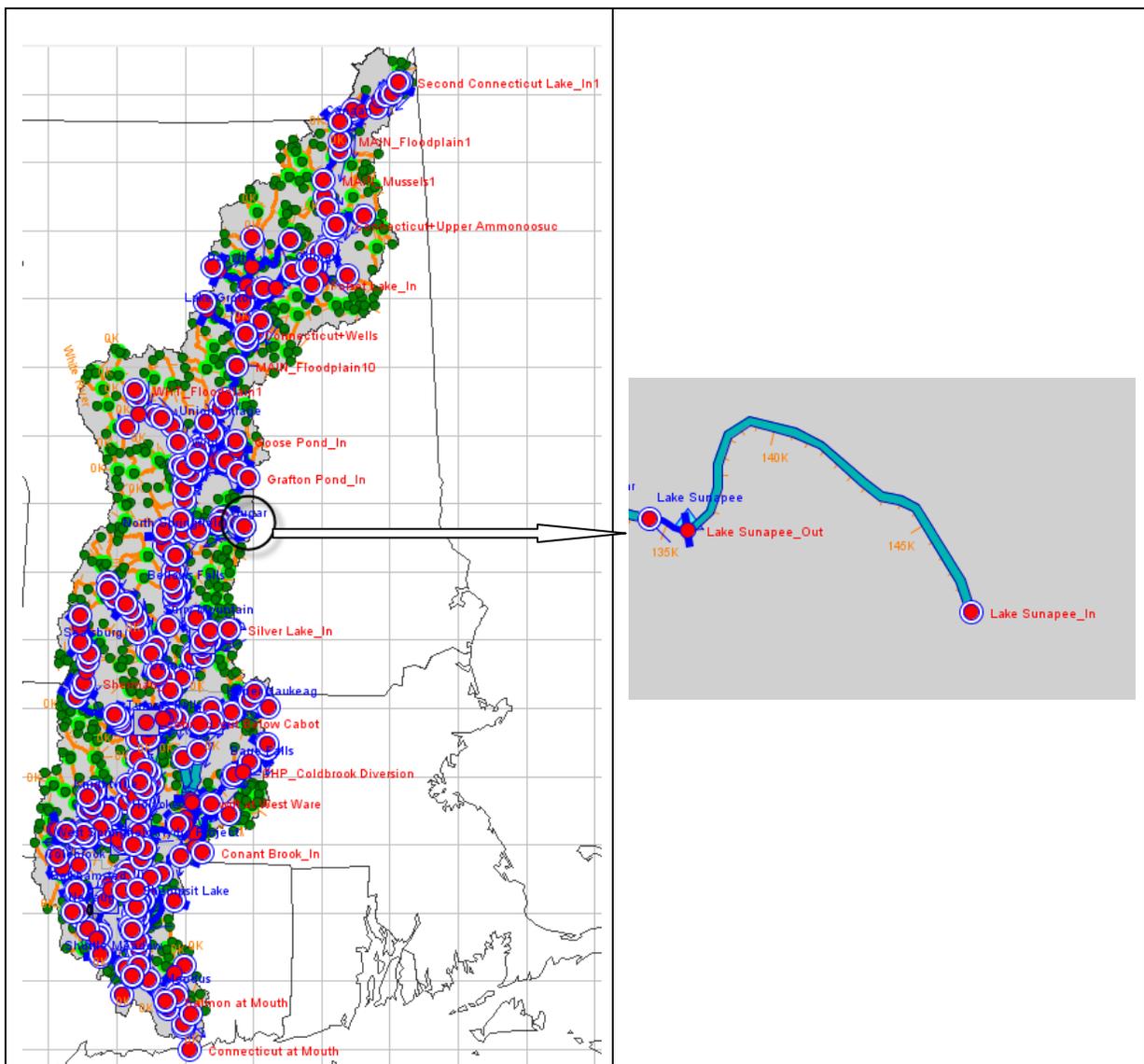


Figure 1: HEC-ResSim Map Display Showing Location of Lake Sunapee Dam



**Figure 2: Photo of Lake Sunapee**

## **II. Physical Characteristics**

The physical characteristics of the reservoir are separated between the Pool and the Dam in the HEC-ResSim model. The elevation-storage-area defines the pool as shown in Figure 3<sup>56</sup>. The dam consists of four types of outlets: (1) controlled Gates, (2) controlled sluice gate, (3) uncontrolled outlet, and (4) power plant as shown in Figure 4<sup>57</sup>.

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<sup>56</sup> NHDams Data Sheet. Lake Sunapee Dam. 2010

<sup>57</sup> Operations & Maintenance Plan. Lake Sunapee Dam. 2008.

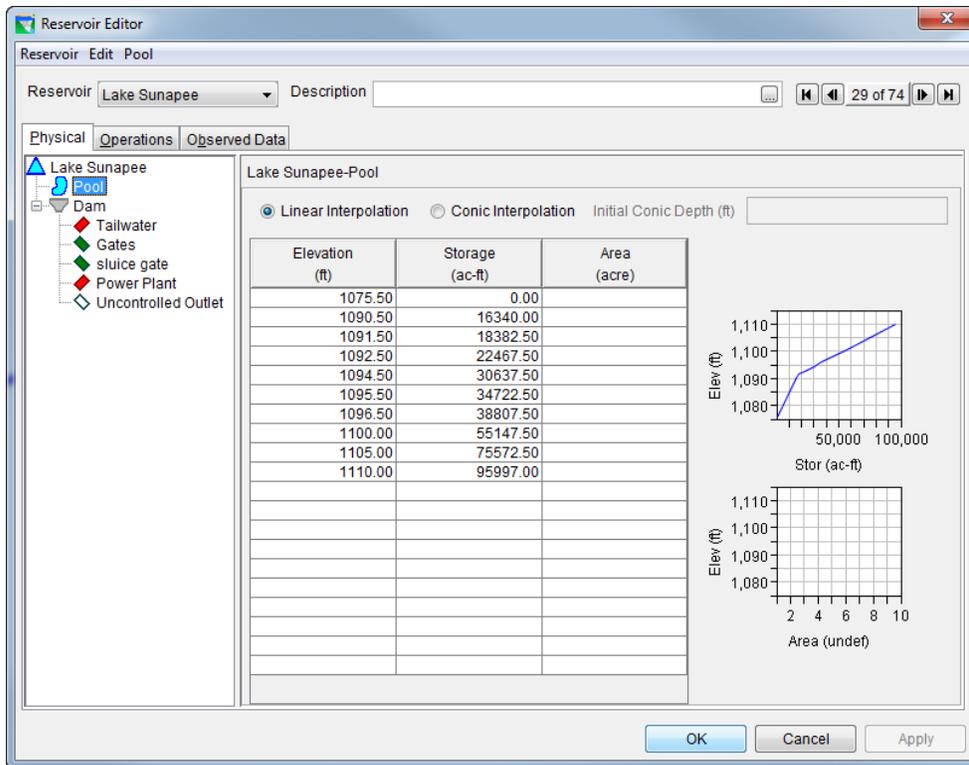


Figure 3: Reservoir Editor: Physical Tab -- Pool

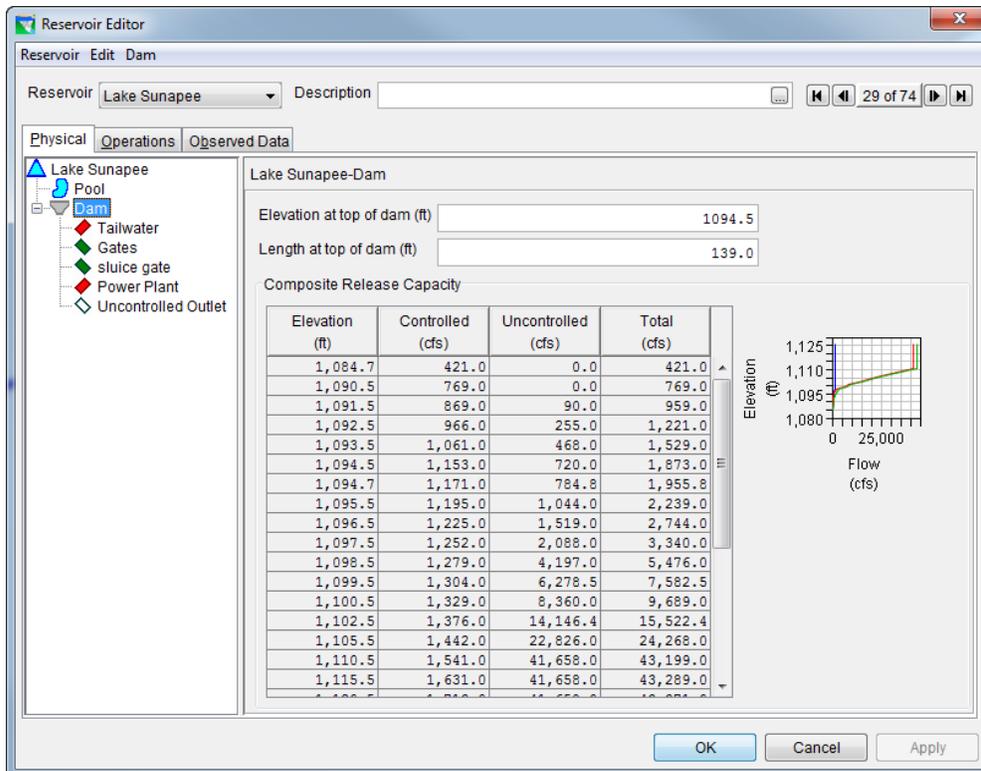


Figure 4: Reservoir Editor: Physical Tab -- Dam



## B. Rule Illustrations

Figure 6 shows a set of operational rules specified for each zone that reflects the operation set named Guide Curve.

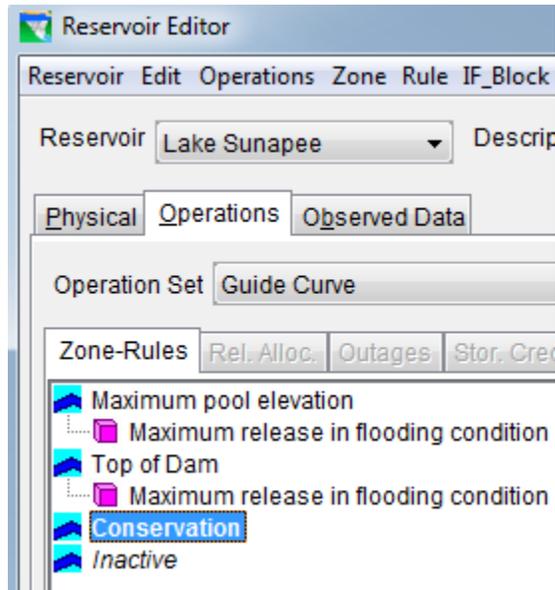


Figure 6: Reservoir Editor: Operations Tab – Guide Curve OpSet – Zones and Rules

## C. Rule Descriptions

### 1. *Maximum release in flooding condition*

Figure 7 shows the content of “Maximum release in flooding condition” rule. This rule represents 750 cfs as a maximum release when the pool elevation is higher than conservation elevation.

Operation Set: Guide Curve | Description: [ ]

Zone-Rules: Rel. Alloc. | Outages | Stor. Credit | Dec. Sched. | Projected Eley

- Maximum pool elevation
- Maximum release in flooding condition**
- Top of Dam
- Maximum release in flooding condition
- Conservation
- Inactive

Operates Release From: Lake Sunapee

Rule Name: lease in flooding condition | Description: [ ]

Function of: Date [ Define... ]

Limit Type: Maximum | Interp.: Linear

Date	Release (cfs)
01Jan	750.0

Release (Cfs) vs. Month (Jan, Mar, May, Jul, Sep, Nov) graph showing a constant release of 750 cfs.

- Period Average Limit [ Edit... ]
- Hour of Day Multiplier [ Edit... ]
- Day of Week Multiplier [ Edit... ]
- Rising/Falling Condition [ Edit... ]
- Seasonal Variation [ Edit... ]

Figure 7: Reservoir Editor: Operations Tab – Guide Curve OpSet – Maximum release in flooding condition

# Littleville

## I. Overview

Littleville Dam is a dam on the Westfield River in Hampden County, Massachusetts. It was constructed in 1965 by the US Army Corps of Engineers and is still owned and operated by the Corps. It is primarily used for flood control purposes but is also used for recreation.

Figure 1 shows the location of Littleville Dam as it is represented in the HEC-ResSim model. Figure 2 shows a photo of the dam.

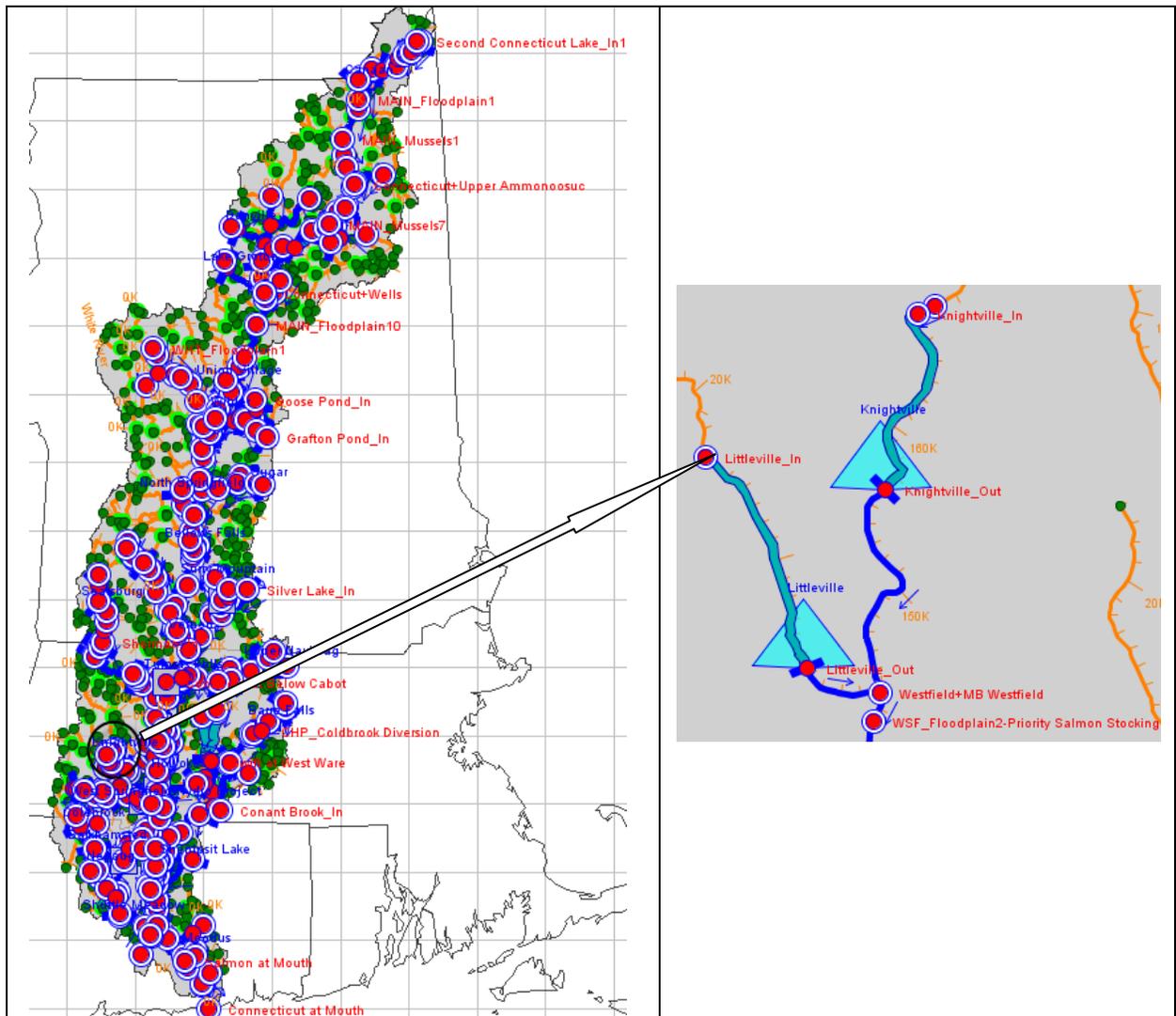


Figure 1: HEC-ResSim Map Display Showing Location of Littleville dam



Figure 2: Photo of Littleville Dam

## II. Physical Characteristics

The physical characteristics of the reservoir are separated between the Pool and the Dam in the HEC-ResSim model. The elevation-storage-area defines the pool as shown in Figure 3. The dam consists of two types of outlets: (1) controlled slide gates, and (2) uncontrolled spillway, as shown in Figure 4. All physical and operations data were provided by US Army Corps New England District, through both personal correspondence and the Reservoir Regulation Team website<sup>58</sup>.

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<sup>58</sup> [http://rsgisias.crrel.usace.army.mil/nae/cwms\\_map.map\\_index](http://rsgisias.crrel.usace.army.mil/nae/cwms_map.map_index)

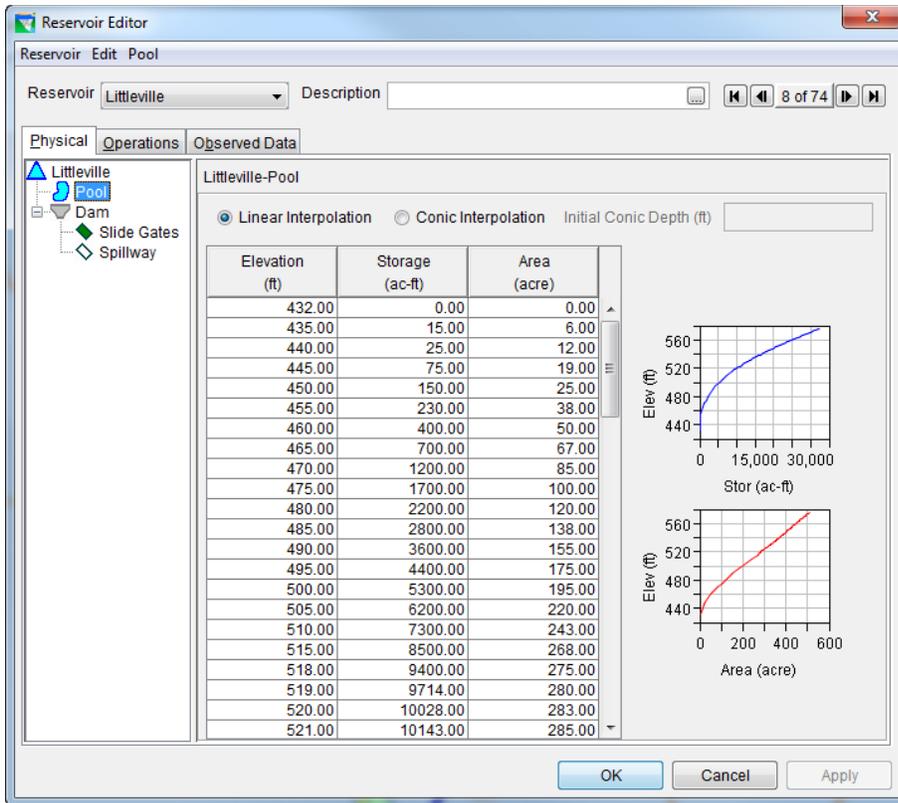


Figure 3: Reservoir Editor: Physical Tab -- Pool

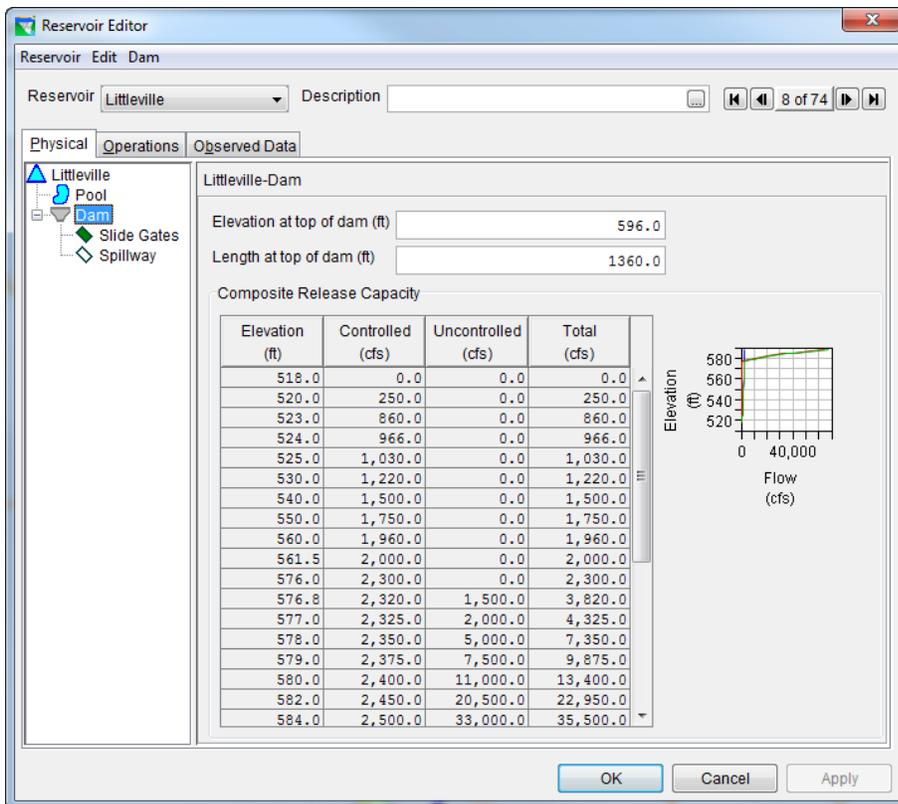


Figure 4: Reservoir Editor: Physical Tab -- Dam



## B. Rule Illustrations

Figure 6 shows a set of operational rules specified for each zone that reflects the operation set named Existing Ops. As described in the Simulation/Verification section of the report, adjustments were made to the operations to closer match gauge data.

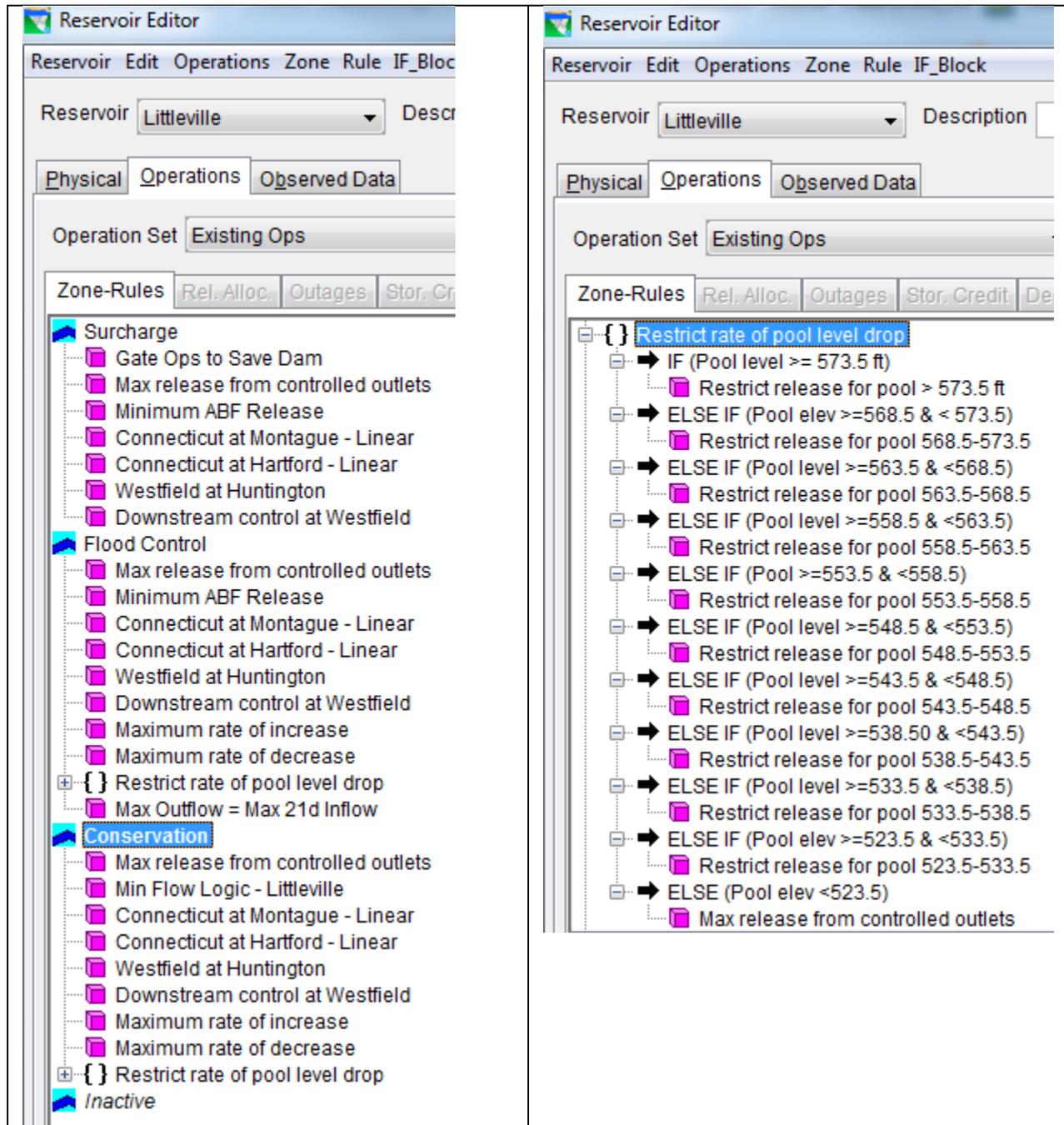


Figure 6: Reservoir Editor: Operations Tab – Existing Ops OpSet – Zones and Rules

## C. Rule Descriptions

### 1. Gate Ops to Save Dam

Figure 7 shows the content of “Gate Ops to Save Dam” rule. This rule represents the maximum allowable release from Slide gates as a function of pool elevation when the pool is in Surcharge zone.

The screenshot displays the 'Operations Tab' for the 'Existing Ops' set. The 'Surcharge' zone is selected, and the 'Gate Ops to Save Dam' rule is highlighted in the tree view. The main configuration area shows the rule name and description, the function of the rule (Littleville-Pool Elevation, Period Average, 0.0 hr lag, 48.0 hr pe), and the limit type (Maximum) and interpolation (Linear). A table shows the release rate (cfs) for various elevations (ft). A graph plots Release (cfs) against Elev (ft), showing a sharp increase from 0 cfs at 578 ft to 2400 cfs at 580 ft, followed by a gradual increase to 2600 cfs at 588 ft. The right side of the interface contains several control options, all of which are currently unchecked.

Elev (ft)	Release (cfs)
576.0	1500.0
576.8	0.0
578.0	0.0
579.0	800.0
580.0	2400.0
582.0	2420.0
585.0	2450.0
588.0	2600.0

Figure 7: Reservoir Editor: Operations Tab – Existing Ops OpSet –Gate Ops to Save Dam





#### 4. Connecticut at Montague-Linear

Figure 10 shows the content of “Connecticut at Montague-Linear” rule. This rule represents the maximum allowable release from the dam as a function of the previous day stage at Montague. The previous day stage was used to account for the delay that occurs between the stage exceeding the specified target and the change in operations at the flood control dams that occurs in reality.

The screenshot shows the 'Operations Tab' in the 'Reservoir Editor' for the 'Existing Ops' set. The 'Connecticut at Montague - Linear' rule is selected in the tree view. The rule configuration is as follows:

- Operates Release From:** Littleville
- Rule Name:** cticut at Montague - Linear
- Function of:** Connecticut at Montague Stage, Previous Value
- Limit Type:** Maximum
- Interp.:** Linear

Stage (ft)	Release (cfs)
0.0	1500.0
26.0	1500.0
27.0	1200.0
28.0	900.0
29.0	600.0
30.0	300.0
31.0	0.0
50.0	0.0

The graph on the right plots Release (cfs) on the y-axis (0 to 1,600) against Stage (ft) on the x-axis (0 to 50). The release is constant at 1500 cfs until the stage reaches 26 ft, then decreases linearly to 0 cfs at 31 ft, and remains at 0 cfs for higher stages.

Additional options on the right include checkboxes for Period Average Limit, Hour of Day Multiplier, Day of Week Multiplier, Rising/Falling Condition, and Seasonal Variation, each with an 'Edit...' button.

Figure 10: Reservoir Editor: Operations Tab – Existing Ops OpSet –Connecticut at Montague-Linear

### 5. Connecticut at Hartford-Linear

Figure 10 shows the content of “Connecticut at Hartford-Linear” rule. This rule represents the maximum allowable release from dam as a function of previous day stage at Hartford. The previous day stage was used to account for the delay that occurs between the stage exceeding the specified target and the change in operations at the flood control dams that occurs in reality.

Operation Set: Existing Ops | Description: [ ]

Zone-Rules: Rel. Alloc. | Outages | Stor. Credit | Dec. Sched. | Projected Elev.

Operates Release From: Littleville

Rule Name: Connecticut at Hartford - Linear | Description: [ ]

Function of: Connecticut at Hartford Stage, Previous Value | Define...

Limit Type: Maximum | Interp.: Linear

Stage (ft)	Release (cfs)
0.0	1500.0
18.0	1500.0
19.0	1200.0
20.0	900.0
21.0	600.0
22.0	300.0
23.0	0.0
50.0	0.0

Graph: Release (cfs) vs Stage (ft). The graph shows a constant release of 1500 cfs for stages up to 18 ft, followed by a linear decrease to 0 cfs at 23 ft, remaining at 0 cfs for higher stages.

Options:

- Period Average Limit | Edit...
- Hour of Day Multiplier | Edit...
- Day of Week Multiplier | Edit...
- Rising/Falling Condition | Edit...
- Seasonal Variation | Edit...

Figure 11: Reservoir Editor: Operations Tab – Existing Ops OpSet – Connecticut at Hartford-Linear

### 6. Westfield at Huntington

Figure 12 shows the content of “Westfield at Huntington” rule. This rule represents the maximum allowable release from dam as a function of previous day stage at Huntington. The previous day stage was used to account for the delay that occurs between the stage exceeding the specified target and the change in operations at the flood control dams that occurs in reality.

Operation Set: Existing Ops | Description: [ ]

Zone-Rules: Rel. Alloc. | Outages | Stor. Credit | Dec. Sched. | Projected Elev.

Operates Release From: Littleville

Rule Name: Westfield at Huntington | Description: [ ]

Function of: Westfield at Huntington Stage, Previous Value | Define...

Limit Type: Maximum | Interp.: Linear

Stage (ft)	Release (cfs)
0.0	1500.0
7.5	1500.0
8.5	1200.0
9.5	900.0
10.5	600.0
11.5	300.0
12.5	0.0
50.0	0.0

Graph: Release (cfs) vs Stage (ft). The graph shows a constant release of 1500 cfs for stages up to 7.5 ft, followed by a linear decrease to 0 cfs at 12.5 ft, and remains at 0 cfs for higher stages.

Options:
 

- Period Average Limit | Edit...
- Hour of Day Multiplier | Edit...
- Day of Week Multiplier | Edit...
- Rising/Falling Condition | Edit...
- Seasonal Variation | Edit...

Figure 12: Reservoir Editor: Operations Tab – Existing Ops OpSet –Westfield at Huntington



### 8. Maximum rate of increase

Figure 14 shows the content of “Maximum rate of increase” rule. This rule shows the maximum allowable increasing release rate of change as a function of release from Littleville dam.

Operation Set: Existing Ops | Description: [ ]

Zone-Rules: Rel. Alloc. | Outages | Stor. Credit | Dec. Sched. | Projected Elev.

- Surcharge
  - Gate Ops to Save Dam
  - Max release from controlled outlets
  - Minimum ABF Release
  - Connecticut at Montague - Linear
  - Connecticut at Hartford - Linear
  - Westfield at Huntington
  - Downstream control at Westfield
- Flood Control
  - Max release from controlled outlets
  - Minimum ABF Release
  - Connecticut at Montague - Linear
  - Connecticut at Hartford - Linear
  - Westfield at Huntington
  - Downstream control at Westfield
  - Maximum rate of increase**
  - Maximum rate of decrease
- Restrict rate of pool level drop [ ]
- Max Outflow = Max 21d Inflow [ ]
- Conservation
  - Max release from controlled outlets
  - Min Flow Logic - Littleville
  - Connecticut at Montague - Linear
  - Connecticut at Hartford - Linear
  - Westfield at Huntington
  - Downstream control at Westfield
  - Maximum rate of increase
  - Maximum rate of decrease
- Restrict rate of pool level drop [ ]
- Inactive

Operates Release From: Littleville-Slide Gates

Release Rate of Change Limit: Maximum rate of increase

Description: [ ]

Function Of: Release

Type: Increasing

Interpolate: Linear

Release (cfs)	Rate Change (cfs/hr)
0.0	300.0
1200.0	300.0
1201.0	100.0
5000.0	100.0

Figure 14: Reservoir Editor: Operations Tab – Existing Ops OpSet –Maximum rate of increase

### 9. Maximum rate of decrease

Figure 15 shows the content of “Maximum rate of decrease” rule. This rule shows the maximum allowable decreasing release rate of change.

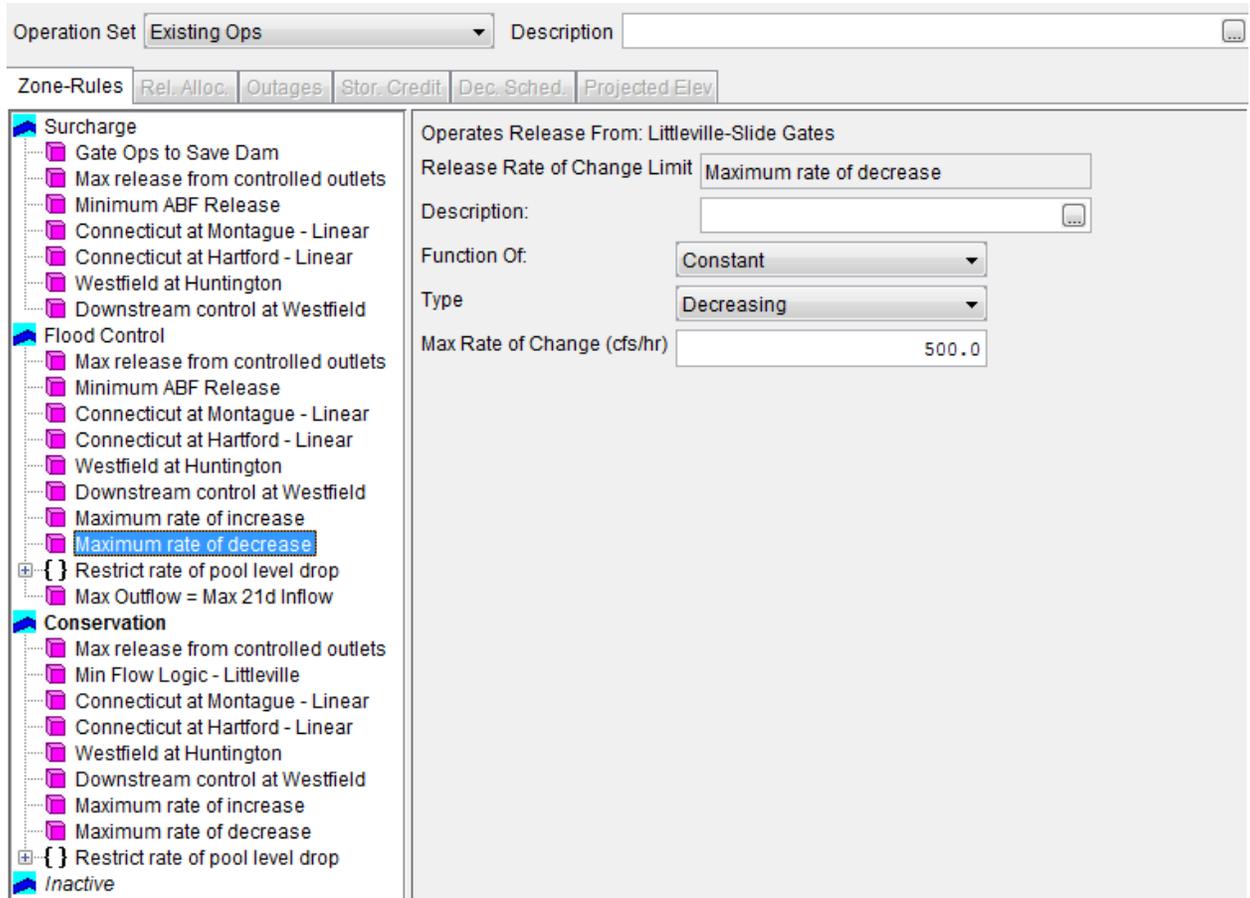


Figure 15: Reservoir Editor: Operations Tab – Existing Ops OpSet –Maximum rate of decrease

### 10. Restrict rate of pool level drop

Figure 15 shows the content of “Restrict rate of pool level drop” rule. It shows the maximum allowable release as a function of Inflow for different ranges of pool elevations.

Operation Set: Existing Ops | Description: [ ]

Zone-Rules: Rel. Alloc. | Outages | Stor. Credit | Dec. Sched. | Projected Elev.

**Restrict rate of pool level drop**

- IF (Pool level >= 573.5 ft)
  - Restrict release for pool > 573.5 ft
- ELSE IF (Pool elev >=568.5 & < 573.5)
  - Restrict release for pool 568.5-573.5
- ELSE IF (Pool level >=563.5 & <568.5)
  - Restrict release for pool 563.5-568.5
- ELSE IF (Pool level >=558.5 & <563.5)
  - Restrict release for pool 558.5-563.5
- ELSE IF (Pool >=553.5 & <558.5)
  - Restrict release for pool 553.5-558.5
- ELSE IF (Pool level >=548.5 & <553.5)
  - Restrict release for pool 548.5-553.5
- ELSE IF (Pool level >=543.5 & <548.5)
  - Restrict release for pool 543.5-548.5
- ELSE IF (Pool level >=538.50 & <543.5)
  - Restrict release for pool 538.5-543.5
- ELSE IF (Pool level >=533.5 & <538.5)
  - Restrict release for pool 533.5-538.5
- ELSE IF (Pool elev >=523.5 & <533.5)
  - Restrict release for pool 523.5-533.5
- ELSE (Pool elev <523.5)
  - Max release from controlled outlets

Operates Release From: Littleville-Slide Gates

Name: Restrict rate of pool level drop | Description: Prevent pool from dropping

Type	Name	Description
IF	Pool level >= 573.5 ft	
ELSE IF	Pool elev >=568.5 & < ...	
ELSE IF	Pool level >=563.5 & <...	
ELSE IF	Pool level >=558.5 & <...	
ELSE IF	Pool >=553.5 & <558.5	
ELSE IF	Pool level >=548.5 & <...	
ELSE IF	Pool level >=543.5 & <...	
ELSE IF	Pool level >=538.50 & ...	
ELSE IF	Pool level >=533.5 & <...	
ELSE IF	Pool elev >=523.5 & <...	
ELSE	Pool elev <523.5	

---

Operation Set: Existing Ops | Description: [ ]

Zone-Rules: Rel. Alloc. | Outages | Stor. Credit | Dec. Sched. | Projected Elev.

**Restrict rate of pool level drop**

- IF (Pool level >= 573.5 ft)
  - Restrict release for pool > 573.5 ft
- ELSE IF (Pool elev >=568.5 & < 573.5)
  - Restrict release for pool 568.5-573.5
- ELSE IF (Pool level >=563.5 & <568.5)
  - Restrict release for pool 563.5-568.5
- ELSE IF (Pool level >=558.5 & <563.5)
  - Restrict release for pool 558.5-563.5
- ELSE IF (Pool >=553.5 & <558.5)
  - Restrict release for pool 553.5-558.5
- ELSE IF (Pool level >=548.5 & <553.5)
  - Restrict release for pool 548.5-553.5
- ELSE IF (Pool level >=543.5 & <548.5)
  - Restrict release for pool 543.5-548.5
- ELSE IF (Pool level >=538.50 & <543.5)
  - Restrict release for pool 538.5-543.5
- ELSE IF (Pool level >=533.5 & <538.5)
  - Restrict release for pool 533.5-538.5
- ELSE IF (Pool elev >=523.5 & <533.5)
  - Restrict release for pool 523.5-533.5
- ELSE (Pool elev <523.5)
  - Max release from controlled outlets

Operates Release From: Littleville-Slide Gates

Rule Name: Restrict release for pool > 573.5 ft | Description: [ ]

Function of: Littleville-Pool Inflow, Current Value | Define...

Limit Type: Maximum | Interp.: Linear

Flow (cfs)	Release (cfs)
0.0	1228.0
272.0	1500.0

Period Average Limit | Edit...  
 Hour of Day Multiplier | Edit...  
 Day of Week Multiplier | Edit...  
 Rising/Falling Condition | Edit...  
 Seasonal Variation | Edit...



Operation Set: Existing Ops Description: [ ]

Zone-Rules: Rel. Alloc. Outages Stor. Credit Dec. Sched. Projected Elev.

**Restrict rate of pool level drop**

- IF (Pool level >= 573.5 ft)
  - Restrict release for pool > 573.5 ft
- ELSE IF (Pool elev >=568.5 & < 573.5)
  - Restrict release for pool 568.5-573.5
- ELSE IF (Pool level >=563.5 & <568.5)
  - Restrict release for pool 563.5-568.5
- ELSE IF (Pool level >=558.5 & <563.5)
  - Restrict release for pool 558.5-563.5**
- ELSE IF (Pool >=553.5 & <558.5)
  - Restrict release for pool 553.5-558.5
- ELSE IF (Pool level >=548.5 & <553.5)
  - Restrict release for pool 548.5-553.5
- ELSE IF (Pool level >=543.5 & <548.5)
  - Restrict release for pool 543.5-548.5
- ELSE IF (Pool level >=538.50 & <543.5)
  - Restrict release for pool 538.5-543.5
- ELSE IF (Pool level >=533.5 & <538.5)
  - Restrict release for pool 533.5-538.5
- ELSE IF (Pool elev >=523.5 & <533.5)
  - Restrict release for pool 523.5-533.5
- ELSE (Pool elev <523.5)
  - Max release from controlled outlets

Operates Release From: Littleville-Slide Gates

Rule Name: lease for pool 558.5-563.5 Description: [ ]

Function of: Littleville-Pool Inflow, Current Value Define...

Limit Type: Maximum Interp.: Linear

Flow (cfs)	Release (cfs)
0.0	1091.0
409.0	1500.0

Period Average Limit Edit...  
 Hour of Day Multiplier Edit...  
 Day of Week Multiplier Edit...  
 Rising/Falling Condition Edit...  
 Seasonal Variation Edit...

---

Operation Set: Existing Ops Description: [ ]

Zone-Rules: Rel. Alloc. Outages Stor. Credit Dec. Sched. Projected Elev.

**Restrict rate of pool level drop**

- IF (Pool level >= 573.5 ft)
  - Restrict release for pool > 573.5 ft
- ELSE IF (Pool elev >=568.5 & < 573.5)
  - Restrict release for pool 568.5-573.5
- ELSE IF (Pool level >=563.5 & <568.5)
  - Restrict release for pool 563.5-568.5
- ELSE IF (Pool level >=558.5 & <563.5)
  - Restrict release for pool 558.5-563.5
- ELSE IF (Pool >=553.5 & <558.5)
  - Restrict release for pool 553.5-558.5**
- ELSE IF (Pool level >=548.5 & <553.5)
  - Restrict release for pool 548.5-553.5
- ELSE IF (Pool level >=543.5 & <548.5)
  - Restrict release for pool 543.5-548.5
- ELSE IF (Pool level >=538.50 & <543.5)
  - Restrict release for pool 538.5-543.5
- ELSE IF (Pool level >=533.5 & <538.5)
  - Restrict release for pool 533.5-538.5
- ELSE IF (Pool elev >=523.5 & <533.5)
  - Restrict release for pool 523.5-533.5
- ELSE (Pool elev <523.5)
  - Max release from controlled outlets

Operates Release From: Littleville-Slide Gates

Rule Name: lease for pool 553.5-558.5 Description: [ ]

Function of: Littleville-Pool Inflow, Current Value Define...

Limit Type: Maximum Interp.: Linear

Flow (cfs)	Release (cfs)
0.0	1053.0
447.0	1500.0

Period Average Limit Edit...  
 Hour of Day Multiplier Edit...  
 Day of Week Multiplier Edit...  
 Rising/Falling Condition Edit...  
 Seasonal Variation Edit...

Operation Set: Existing Ops    Description:

Zone-Rules: Rel. Alloc. | Outages | Stor. Credit | Dec. Sched. | Projected Eley

**{}** Restrict rate of pool level drop

- IF (Pool level >= 573.5 ft)
  - Restrict release for pool > 573.5 ft
- ELSE IF (Pool elev >=568.5 & < 573.5)
  - Restrict release for pool 568.5-573.5
- ELSE IF (Pool level >=563.5 & <568.5)
  - Restrict release for pool 563.5-568.5
- ELSE IF (Pool level >=558.5 & <563.5)
  - Restrict release for pool 558.5-563.5
- ELSE IF (Pool >=553.5 & <558.5)
  - Restrict release for pool 553.5-558.5
- ELSE IF (Pool level >=548.5 & <553.5)
  - Restrict release for pool 548.5-553.5**
- ELSE IF (Pool level >=543.5 & <548.5)
  - Restrict release for pool 543.5-548.5
- ELSE IF (Pool level >=538.50 & <543.5)
  - Restrict release for pool 538.5-543.5
- ELSE IF (Pool level >=533.5 & <538.5)
  - Restrict release for pool 533.5-538.5
- ELSE IF (Pool elev >=523.5 & <533.5)
  - Restrict release for pool 523.5-533.5
- ELSE (Pool elev <523.5)
  - Max release from controlled outlets

Operates Release From: Littleville-Slide Gates

Rule Name: lease for pool 548.5-553.5    Description:

Function of: Littleville-Pool Inflow, Current Value    Define...

Limit Type: Maximum    Interp.: Linear

Flow (cfs)	Release (cfs)
0.0	996.0
504.0	1500.0

Period Average Limit    Edit...  
 Hour of Day Multiplier    Edit...  
 Day of Week Multiplier    Edit...  
 Rising/Falling Condition    Edit...  
 Seasonal Variation    Edit...

---

Operation Set: Existing Ops    Description:

Zone-Rules: Rel. Alloc. | Outages | Stor. Credit | Dec. Sched. | Projected Eley

**{}** Restrict rate of pool level drop

- IF (Pool level >= 573.5 ft)
  - Restrict release for pool > 573.5 ft
- ELSE IF (Pool elev >=568.5 & < 573.5)
  - Restrict release for pool 568.5-573.5
- ELSE IF (Pool level >=563.5 & <568.5)
  - Restrict release for pool 563.5-568.5
- ELSE IF (Pool level >=558.5 & <563.5)
  - Restrict release for pool 558.5-563.5
- ELSE IF (Pool >=553.5 & <558.5)
  - Restrict release for pool 553.5-558.5
- ELSE IF (Pool level >=548.5 & <553.5)
  - Restrict release for pool 548.5-553.5
- ELSE IF (Pool level >=543.5 & <548.5)
  - Restrict release for pool 543.5-548.5**
- ELSE IF (Pool level >=538.50 & <543.5)
  - Restrict release for pool 538.5-543.5
- ELSE IF (Pool level >=533.5 & <538.5)
  - Restrict release for pool 533.5-538.5
- ELSE IF (Pool elev >=523.5 & <533.5)
  - Restrict release for pool 523.5-533.5
- ELSE (Pool elev <523.5)
  - Max release from controlled outlets

Operates Release From: Littleville-Slide Gates

Rule Name: lease for pool 543.5-548.5    Description:

Function of: Littleville-Pool Inflow, Current Value    Define...

Limit Type: Maximum    Interp.: Linear

Flow (cfs)	Release (cfs)
0.0	952.0
548.0	1500.0

Period Average Limit    Edit...  
 Hour of Day Multiplier    Edit...  
 Day of Week Multiplier    Edit...  
 Rising/Falling Condition    Edit...  
 Seasonal Variation    Edit...

299

Operation Set: Existing Ops    Description:

Zone-Rules: Rel. Alloc. | Outages | Stor. Credit | Dep. Sched. | Projected Elev.

Restrict rate of pool level drop

- IF (Pool level >= 573.5 ft)
  - Restrict release for pool > 573.5 ft
- ELSE IF (Pool elev >=568.5 & < 573.5)
  - Restrict release for pool 568.5-573.5
- ELSE IF (Pool level >=563.5 & <568.5)
  - Restrict release for pool 563.5-568.5
- ELSE IF (Pool level >=558.5 & <563.5)
  - Restrict release for pool 558.5-563.5
- ELSE IF (Pool >=553.5 & <558.5)
  - Restrict release for pool 553.5-558.5
- ELSE IF (Pool level >=548.5 & <553.5)
  - Restrict release for pool 548.5-553.5
- ELSE IF (Pool level >=543.5 & <548.5)
  - Restrict release for pool 543.5-548.5
- ELSE IF (Pool level >=538.50 & <543.5)
  - Restrict release for pool 538.5-543.5**
- ELSE IF (Pool level >=533.5 & <538.5)
  - Restrict release for pool 533.5-538.5
- ELSE IF (Pool elev >=523.5 & <533.5)
  - Restrict release for pool 523.5-533.5
- ELSE (Pool elev <523.5)
  - Max release from controlled outlets

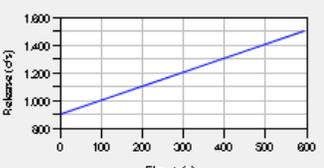
Operates Release From: Littleville-Slide Gates

Rule Name:     Description:

Function of:     Define...

Limit Type:     Interp.:

Flow (cfs)	Release (cfs)
0.0	905.0
595.0	1500.0



Period Average Limit    Edit...  
 Hour of Day Multiplier    Edit...  
 Day of Week Multiplier    Edit...  
 Rising/Falling Condition    Edit...  
 Seasonal Variation    Edit...

---

Operation Set: Existing Ops    Description:

Zone-Rules: Rel. Alloc. | Outages | Stor. Credit | Dep. Sched. | Projected Elev.

Restrict rate of pool level drop

- IF (Pool level >= 573.5 ft)
  - Restrict release for pool > 573.5 ft
- ELSE IF (Pool elev >=568.5 & < 573.5)
  - Restrict release for pool 568.5-573.5
- ELSE IF (Pool level >=563.5 & <568.5)
  - Restrict release for pool 563.5-568.5
- ELSE IF (Pool level >=558.5 & <563.5)
  - Restrict release for pool 558.5-563.5
- ELSE IF (Pool >=553.5 & <558.5)
  - Restrict release for pool 553.5-558.5
- ELSE IF (Pool level >=548.5 & <553.5)
  - Restrict release for pool 548.5-553.5
- ELSE IF (Pool level >=543.5 & <548.5)
  - Restrict release for pool 543.5-548.5
- ELSE IF (Pool level >=538.50 & <543.5)
  - Restrict release for pool 538.5-543.5
- ELSE IF (Pool level >=533.5 & <538.5)
  - Restrict release for pool 533.5-538.5**
- ELSE IF (Pool elev >=523.5 & <533.5)
  - Restrict release for pool 523.5-533.5
- ELSE (Pool elev <523.5)
  - Max release from controlled outlets

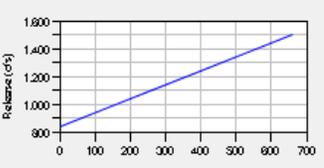
Operates Release From: Littleville-Slide Gates

Rule Name:     Description:

Function of:     Define...

Limit Type:     Interp.:

Flow (cfs)	Release (cfs)
0.0	840.0
660.0	1500.0



Period Average Limit    Edit...  
 Hour of Day Multiplier    Edit...  
 Day of Week Multiplier    Edit...  
 Rising/Falling Condition    Edit...  
 Seasonal Variation    Edit...

300

Operation Set Existing Ops Description

Zone-Rules Rel. Alloc. Outages Stor. Credit Dec. Sched. Projected Elev

**Restrict rate of pool level drop**

- IF (Pool level >= 573.5 ft)
  - Restrict release for pool > 573.5 ft
- ELSE IF (Pool elev >=568.5 & < 573.5)
  - Restrict release for pool 568.5-573.5
- ELSE IF (Pool level >=563.5 & <568.5)
  - Restrict release for pool 563.5-568.5
- ELSE IF (Pool level >=558.5 & <563.5)
  - Restrict release for pool 558.5-563.5
- ELSE IF (Pool >=553.5 & <558.5)
  - Restrict release for pool 553.5-558.5
- ELSE IF (Pool level >=548.5 & <553.5)
  - Restrict release for pool 548.5-553.5
- ELSE IF (Pool level >=543.5 & <548.5)
  - Restrict release for pool 543.5-548.5
- ELSE IF (Pool level >=538.50 & <543.5)
  - Restrict release for pool 538.5-543.5
- ELSE IF (Pool level >=533.5 & <538.5)
  - Restrict release for pool 533.5-538.5
- ELSE IF (Pool elev >=523.5 & <533.5)
  - Restrict release for pool 523.5-533.5
- ELSE (Pool elev <523.5)
  - Max release from controlled outlets

Operates Release From: Littleville-Slide Gates

Rule Name: lease for pool 523.5-533.5 Description:

Function of: Littleville-Pool Inflow, Current Value Define...

Limit Type: Maximum Interp.: Linear

Flow (cfs)	Release (cfs)
0.0	785.0
715.0	1500.0

Period Average Limit Edit...  
 Hour of Day Multiplier Edit...  
 Day of Week Multiplier Edit...  
 Rising/Falling Condition Edit...  
 Seasonal Variation Edit...

---

Operation Set Existing Ops Description

Zone-Rules Rel. Alloc. Outages Stor. Credit Dec. Sched. Projected Elev

**Restrict rate of pool level drop**

- IF (Pool level >= 573.5 ft)
  - Restrict release for pool > 573.5 ft
- ELSE IF (Pool elev >=568.5 & < 573.5)
  - Restrict release for pool 568.5-573.5
- ELSE IF (Pool level >=563.5 & <568.5)
  - Restrict release for pool 563.5-568.5
- ELSE IF (Pool level >=558.5 & <563.5)
  - Restrict release for pool 558.5-563.5
- ELSE IF (Pool >=553.5 & <558.5)
  - Restrict release for pool 553.5-558.5
- ELSE IF (Pool level >=548.5 & <553.5)
  - Restrict release for pool 548.5-553.5
- ELSE IF (Pool level >=543.5 & <548.5)
  - Restrict release for pool 543.5-548.5
- ELSE IF (Pool level >=538.50 & <543.5)
  - Restrict release for pool 538.5-543.5
- ELSE IF (Pool level >=533.5 & <538.5)
  - Restrict release for pool 533.5-538.5
- ELSE IF (Pool elev >=523.5 & <533.5)
  - Restrict release for pool 523.5-533.5
- ELSE (Pool elev <523.5)
  - Max release from controlled outlets

Operates Release From: Littleville-Slide Gates

Rule Name: ase from controlled outlets Description:

Function of: Date Define...

Limit Type: Maximum Interp.: Linear

Date	Release (cfs)
01Jan	1500.0

Period Average Limit Edit...  
 Hour of Day Multiplier Edit...  
 Day of Week Multiplier Edit...  
 Rising/Falling Condition Edit...  
 Seasonal Variation Edit...

Figure 16: Reservoir Editor: Operations Tab – Existing Ops OpSet –Restrict rate of pool level drop

### 11. Max Outflow equals 21 day max Inflow

Figure 17 shows the content of “Max Outflow equals 21 day max Inflow” rule. This rule represents the maximum release from dam as a function of the previous 3 weeks of inflow.

The screenshot shows the 'Operations' tab in the Reservoir Editor. The 'Zone-Rules' tree on the left has 'Max Outflow = Max 21d Inflow' selected under the 'Flood Control' category. The main configuration area shows the following details:

- Operates Release From:** Littleville
- Rule Name:** x Outflow = Max 21d Inflow
- Function of:** Littleville-Pool Inflow, Period Maximum, 0.0 hr lag, 504.0 hr period
- Limit Type:** Maximum
- Interp.:** Linear

A table displays the relationship between flow and release:

Flow (cfs)	Release (cfs)
0.0	0.0
1500.0	1500.0
123456.0	1500.0

To the right of the table is a graph with 'Flow (cfs)' on the x-axis (0 to 120,000) and 'Release (cfs)' on the y-axis (0 to 1,600). The graph shows a horizontal line at a release of 1,500 cfs for flow values above 1,500 cfs. Below the graph are several unchecked options: Period Average Limit, Hour of Day Multiplier, Day of Week Multiplier, Rising/Falling Condition, and Seasonal Variation.

Figure 17: Reservoir Editor: Operations Tab – Existing Ops OpSet – Max Outflow equals 21 day max Inflow

### 12. Min Flow Logic - Littleville

Figure 18 shows the content of “Min Flow Logic - Littleville” rule. This rule describes required seasonal minimum flows from controlled outlets as a function of inflow at Littleville.

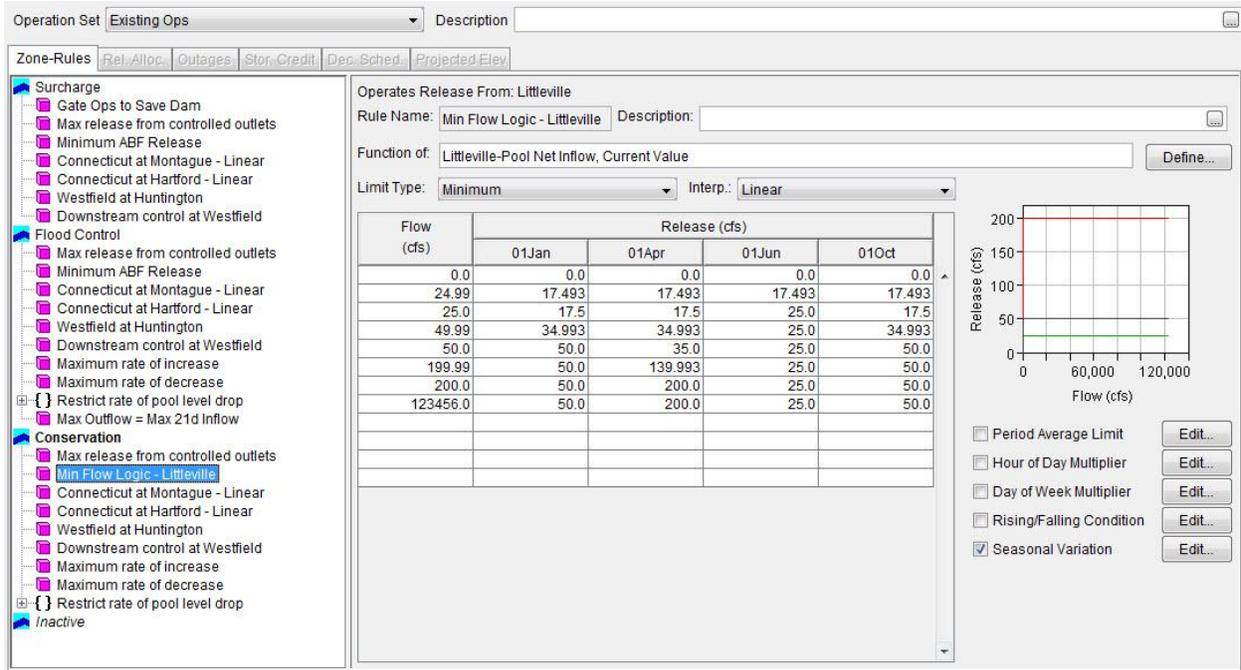


Figure 18: Reservoir Editor: Operations Tab – Existing Ops OpSet – Min Flow Logic - Littleville

# Mare Meadow

## I. Overview

Mare Meadow dam is on the Mare Meadow River in Worcester County, Massachusetts. It is owned by the City Of Fitchburg and is primarily used for drinking water supply for the city.

Figure 1 shows the location of Mare Meadow Dam as it is represented in the HEC-ResSim model. Figure 2 shows a photo of the dam.

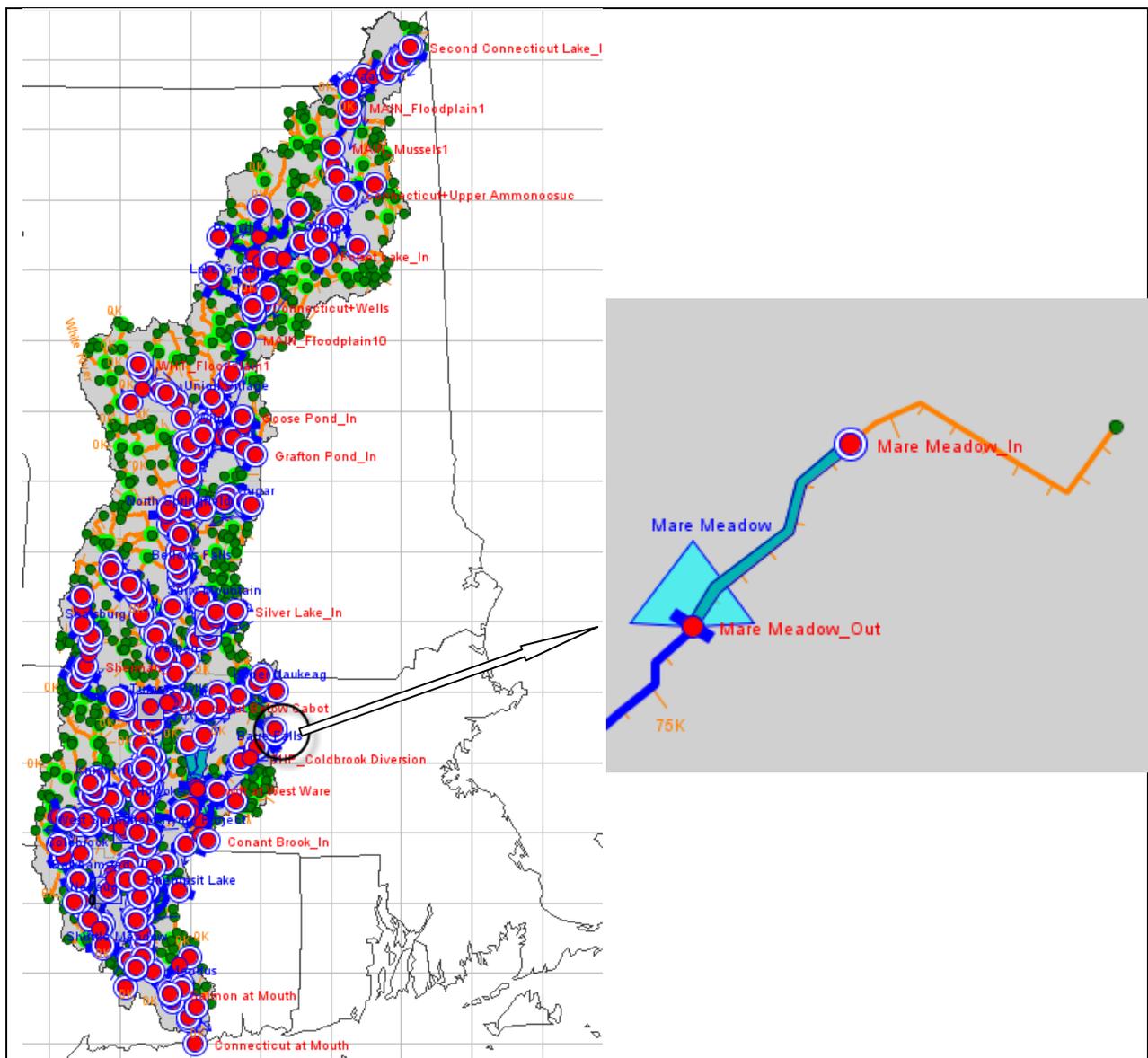


Figure 1: HEC-ResSim Map Display Showing Location of Mare Meadow



Figure 2: Aerial photo of Mare Meadow reservoir.

## II. Physical Characteristics

The physical characteristics of the reservoir are separated between the Pool and the Dam in the HEC-ResSim model. The elevation-storage-area defines the pool as shown in Figure 3<sup>59</sup>. The dam consists of a controlled outlet and an uncontrolled spillway as shown in Figure 4.

---

<sup>59</sup> Provided by UMASS



### III. Operations

#### A. Operation Set

Zones are used to define the operational storage in the reservoir to determine the reservoir release through analysis of the rules contained within each zone. Figure 5 shows the definition of Mare Meadow’s “Existing Ops” operational zones, which consist of zones of Flood Control (1066.5 ft), Conservation (1060.5 ft), and Inactive zone (1020 ft)<sup>1</sup>.

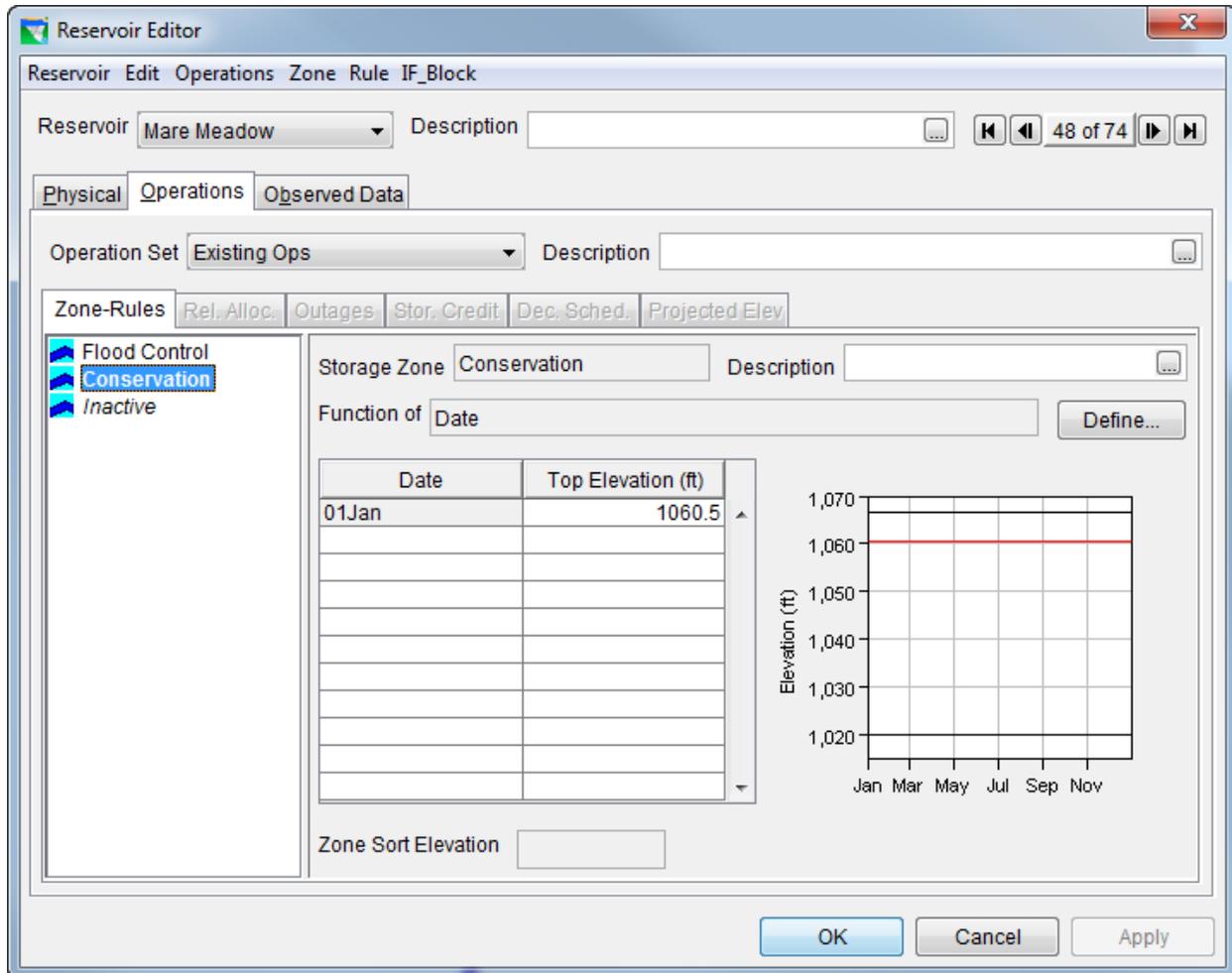


Figure 5: Reservoir Editor: Operations Tab – Existing Ops OpSet

#### B. Rule Illustrations

The operation set for Mare Meadow has no rules of operation making it a flow through reservoir. The pool elevation will remain at the top of conservation unless the inflow exceeds the total release capacity.

# Mascoma

## I. Overview

Mascoma Lake dam is located 3 miles upstream of the city of Lebanon on the Mascoma River. It is currently owned and operated by the New Hampshire Water Resources Board and is used for several purposes: water supply for the City of Lebanon, recreation, and some flood control.

Figure 1 shows the location of Mascoma dam as it is represented in the HEC-ResSim model. Figure 2 shows a photo of Mascoma dam.

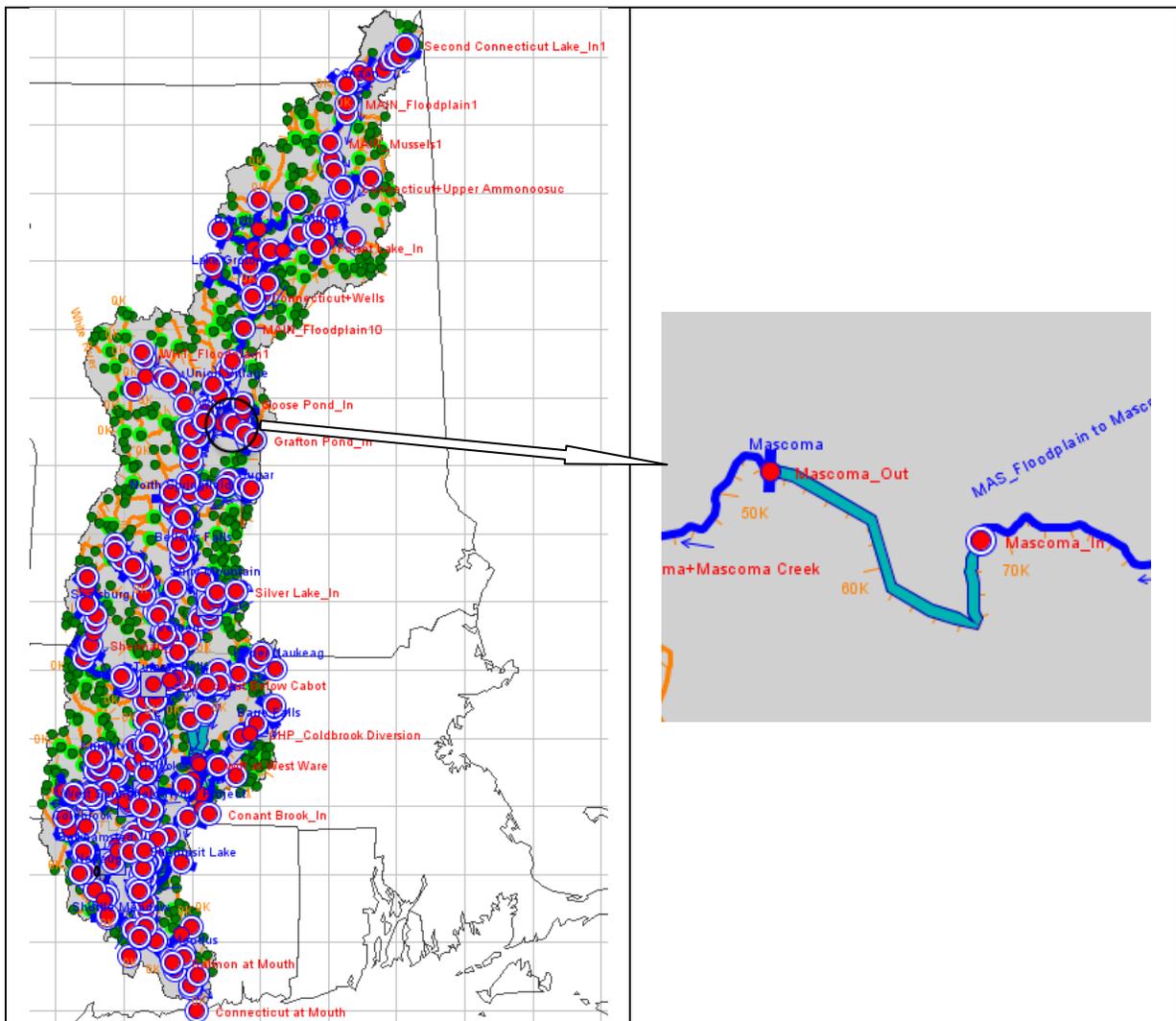


Figure 1: HEC-ResSim Map Display Showing Location of Mascoma Dam



**Figure 2: Photo of Mascoma dam.**

## **II. Physical Characteristics**

The physical characteristics of the reservoir are separated between the Pool and the Dam in the HEC-ResSim model. The elevation-storage-area defines the pool as shown in Figure 3<sup>60</sup>. The dam consists of three types of outlets: (1) controlled slide gates, (2) controlled Obermeyer gate on aux spillway, and (3) uncontrolled Main Spillway, as shown in Figure 4<sup>61</sup>.

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<sup>60</sup> NHDams Data Sheet. Mascoma Dam. 2010

<sup>61</sup> Phase 1 Report. Mascoma Dam. 1978.

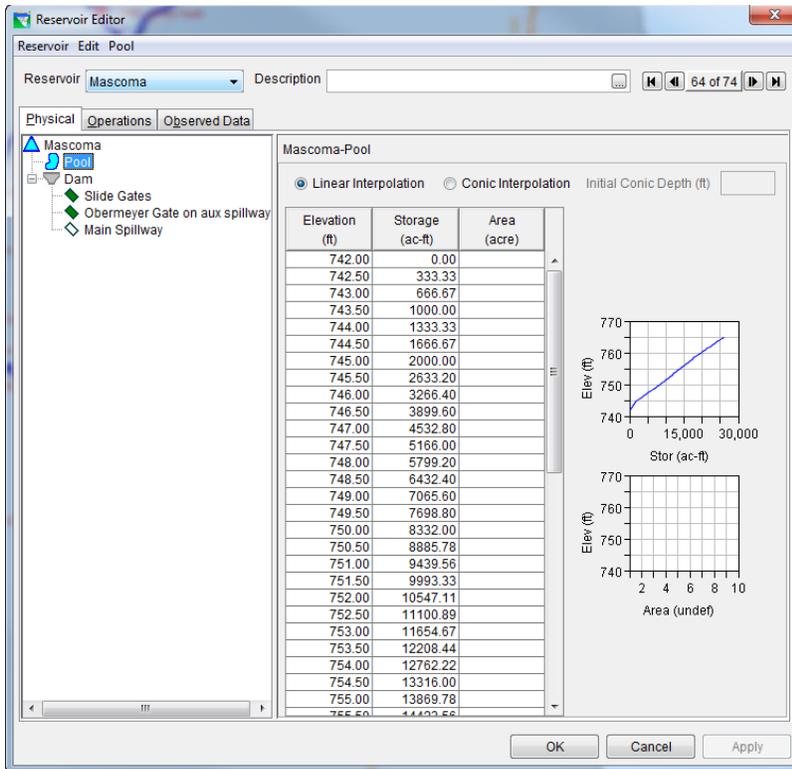


Figure 3: Reservoir Editor: Physical Tab – Pool

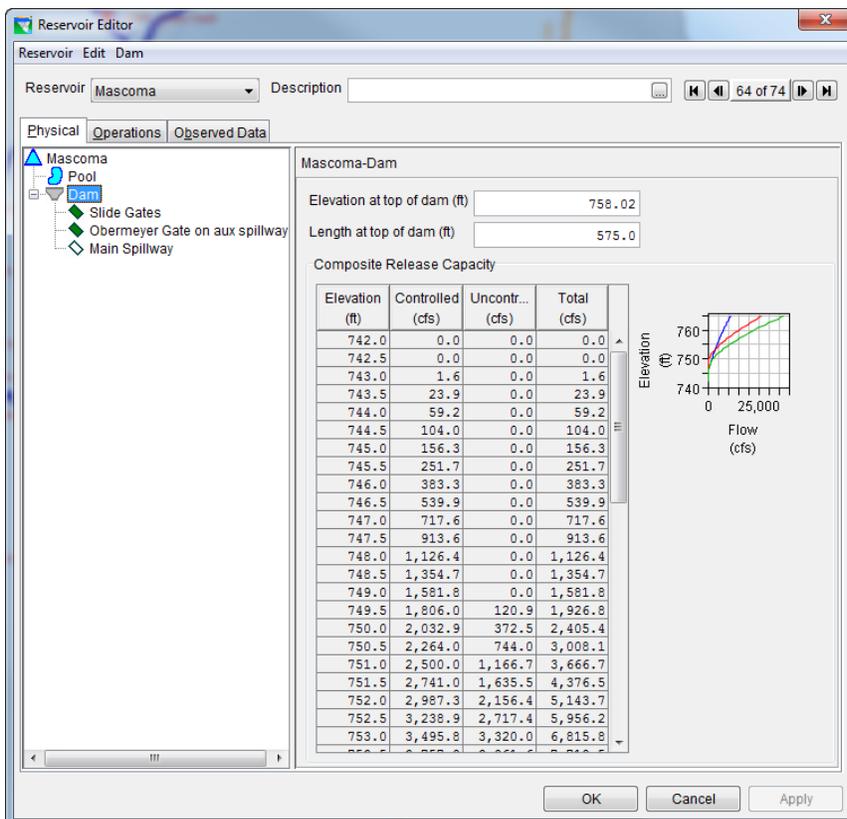


Figure 4: Reservoir Editor: Physical Tab -- Dam

### III. Operations

#### A. Operation Set

Zones are used to define the operational storage in the reservoir to determine the reservoir release through analysis of the rules contained within each zone. Figure 5 shows the definition of Mascoma Dam’s “ExistingOps” operational zones, which consist of zones of Flood Control (758.02 ft), Conservation (748-751 ft), and Inactive zone (742 ft)<sup>62</sup>.

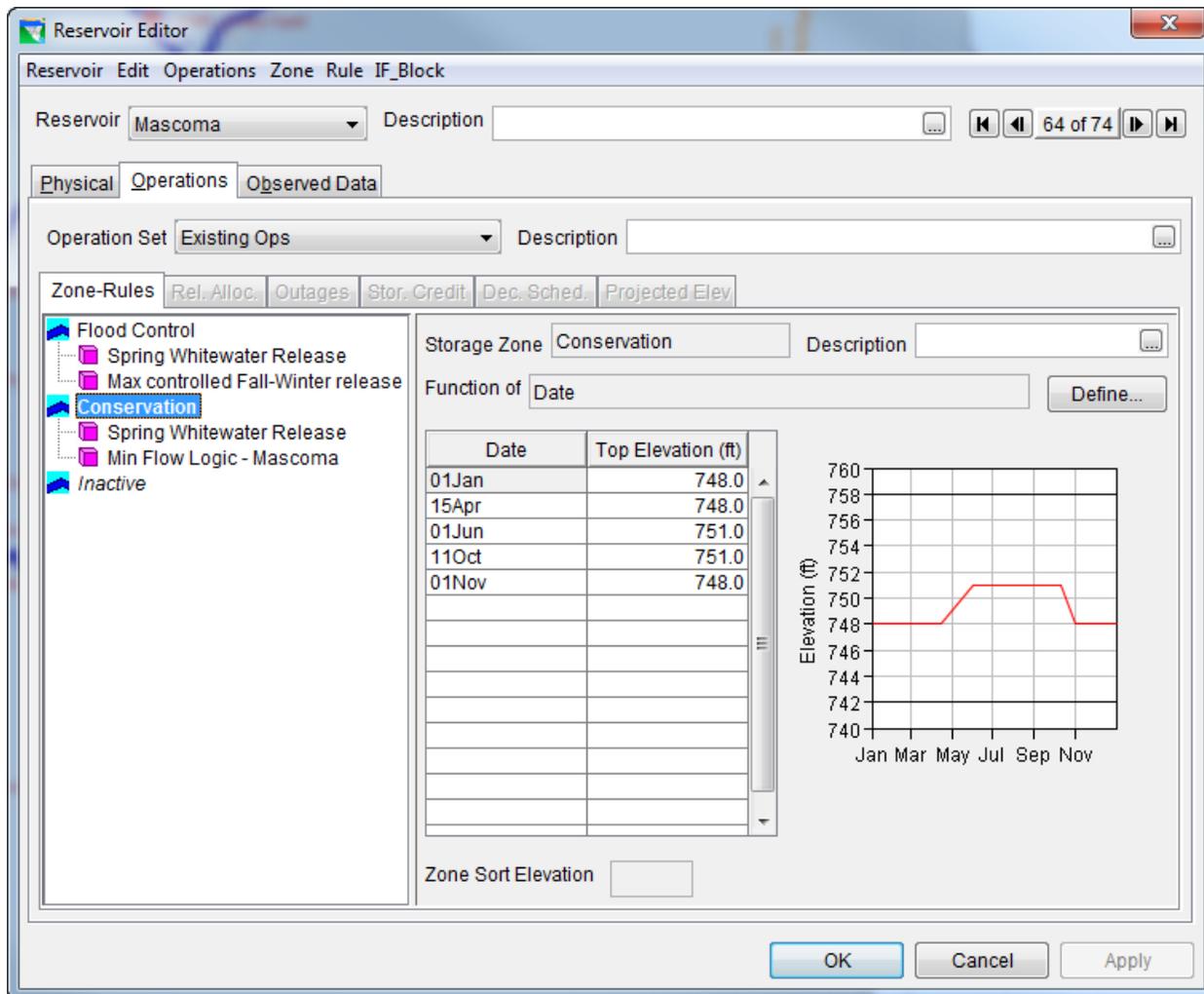


Figure 5: Reservoir Editor: Operations Tab –Existing Ops OpSet – Guide Curve

<sup>62</sup>[http://www2.des.state.nh.us/rti\\_home/station\\_information\\_display.asp?WID=fivebasins&ID=MCAN3&NAME=Mascoma+Lake](http://www2.des.state.nh.us/rti_home/station_information_display.asp?WID=fivebasins&ID=MCAN3&NAME=Mascoma+Lake)

## B. Rule Illustrations

Figure 6 shows a set of operational rules specified for each zone that reflects the operation set named Existing Ops<sup>63</sup>.

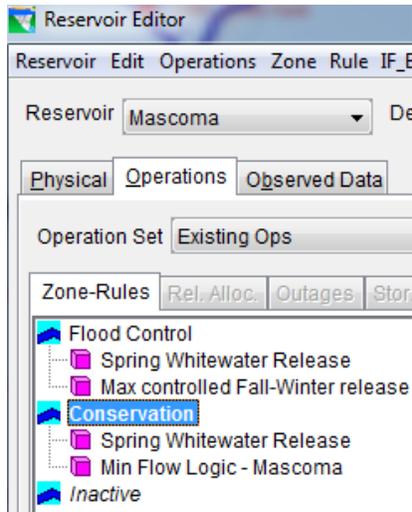


Figure 6: Reservoir Editor: Operations Tab – Existing Ops OpSet – Zones and Rules

## C. Rule Descriptions

### 1. Spring Whitewater release

Figure 7 shows the content of “Spring Whitewater Release” rule. This rule defines a seasonal maximum release from reservoir as a function of Inflow.

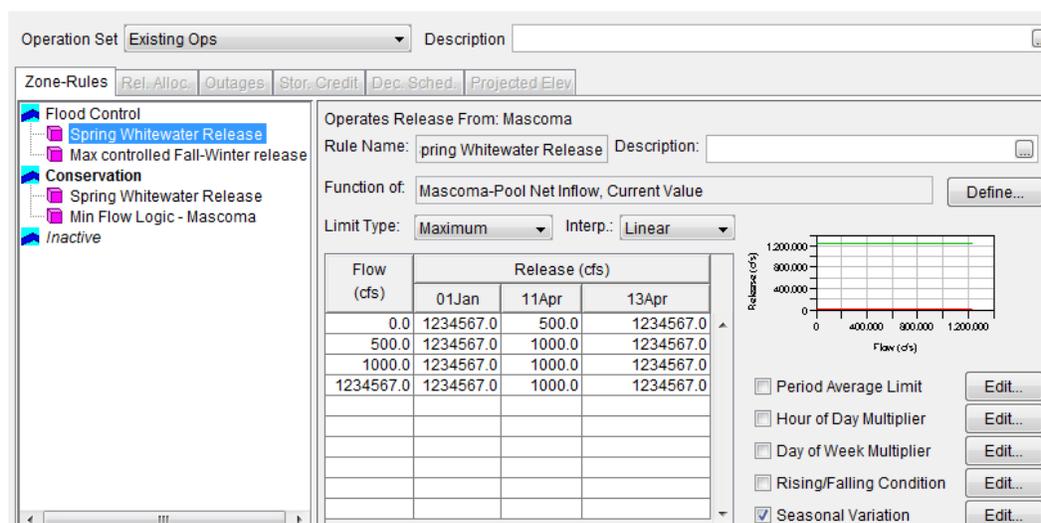


Figure 7: Reservoir Editor: Operations Tab – Existing Ops OpSet – Spring Whitewater Release

<sup>63</sup> Mascoma Lake Operating Guide. 1985.

### 2. Max controlled Fall-Winter release

Figure 8 shows the content of “Max controlled Fall-Winter release” rule. This rule limits the maximum release from Dam to 2000 cfs during 15Apr-31May.

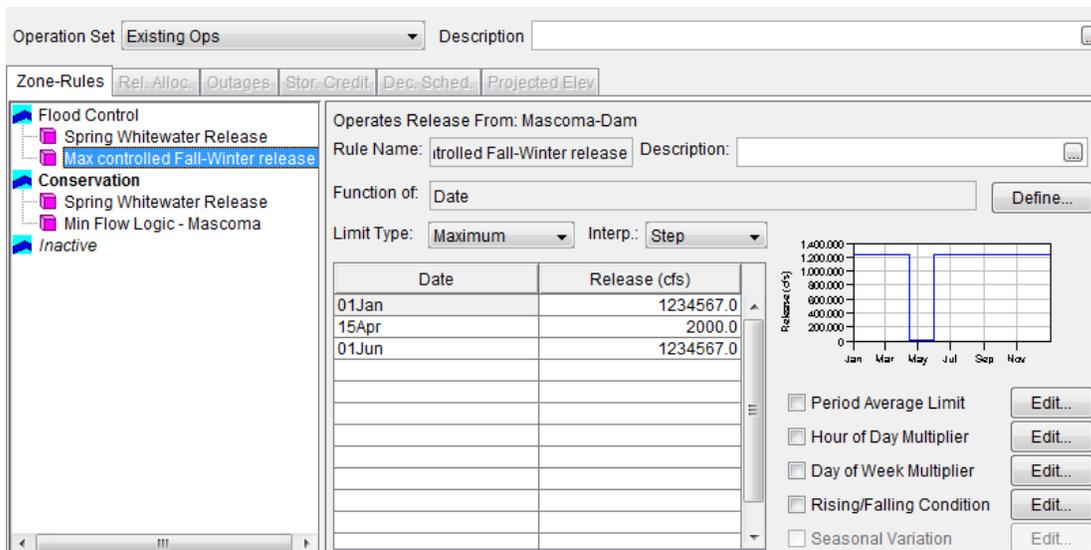


Figure 8: Reservoir Editor: Operations Tab – Existing Ops OpSet – Max controlled Fall-Winter release

### 3. Min Flow logic-Mascoma

Figure 9 shows the content of “Min Flow logic-Mascoma” rule. This rule represents the seasonal minimum flow from reservoir as a function of Inflow.

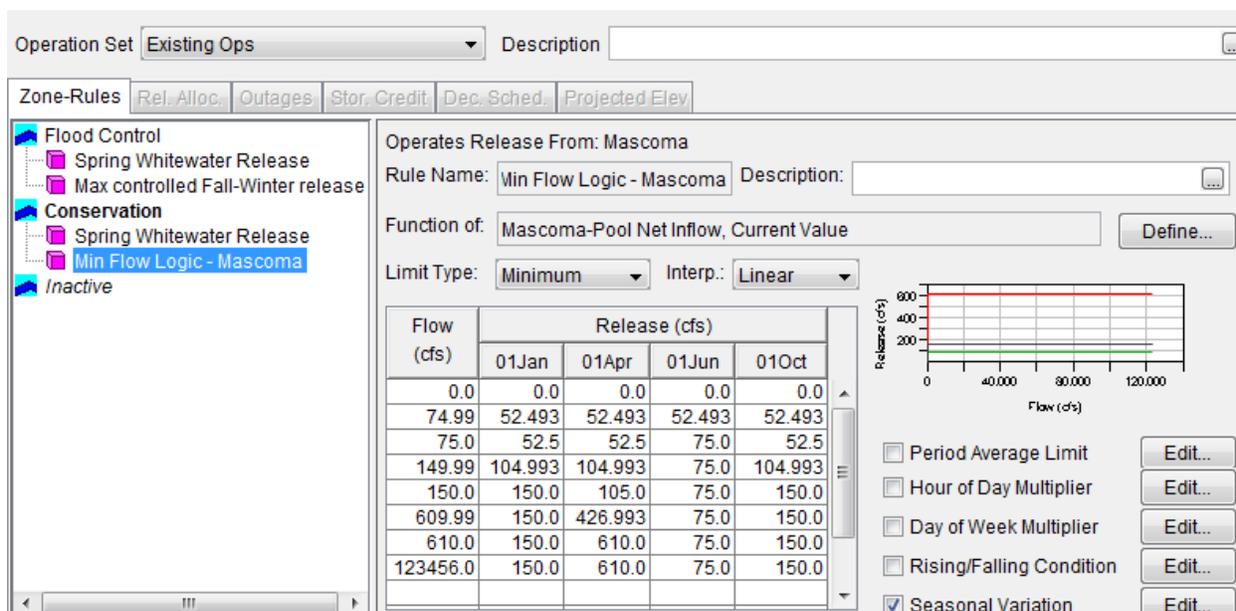


Figure 9: Reservoir Editor: Operations Tab – Existing Ops OpSet – Min Flow logic-Mascoma

## McIndoes

### I. Overview

McIndoes dam is located on the mainstem Connecticut River between Monroe, NH and Barnet, VT. It is owned and operated by TransCanada Hydro Northeast Inc. as part of the 15 Mile Falls project for hydropower generation on run-of-river basis.

Figure 1 shows the location of McIndoes dam as it is represented in the HEC-ResSim model. Figure 2 shows a photo of McIndoes dam.

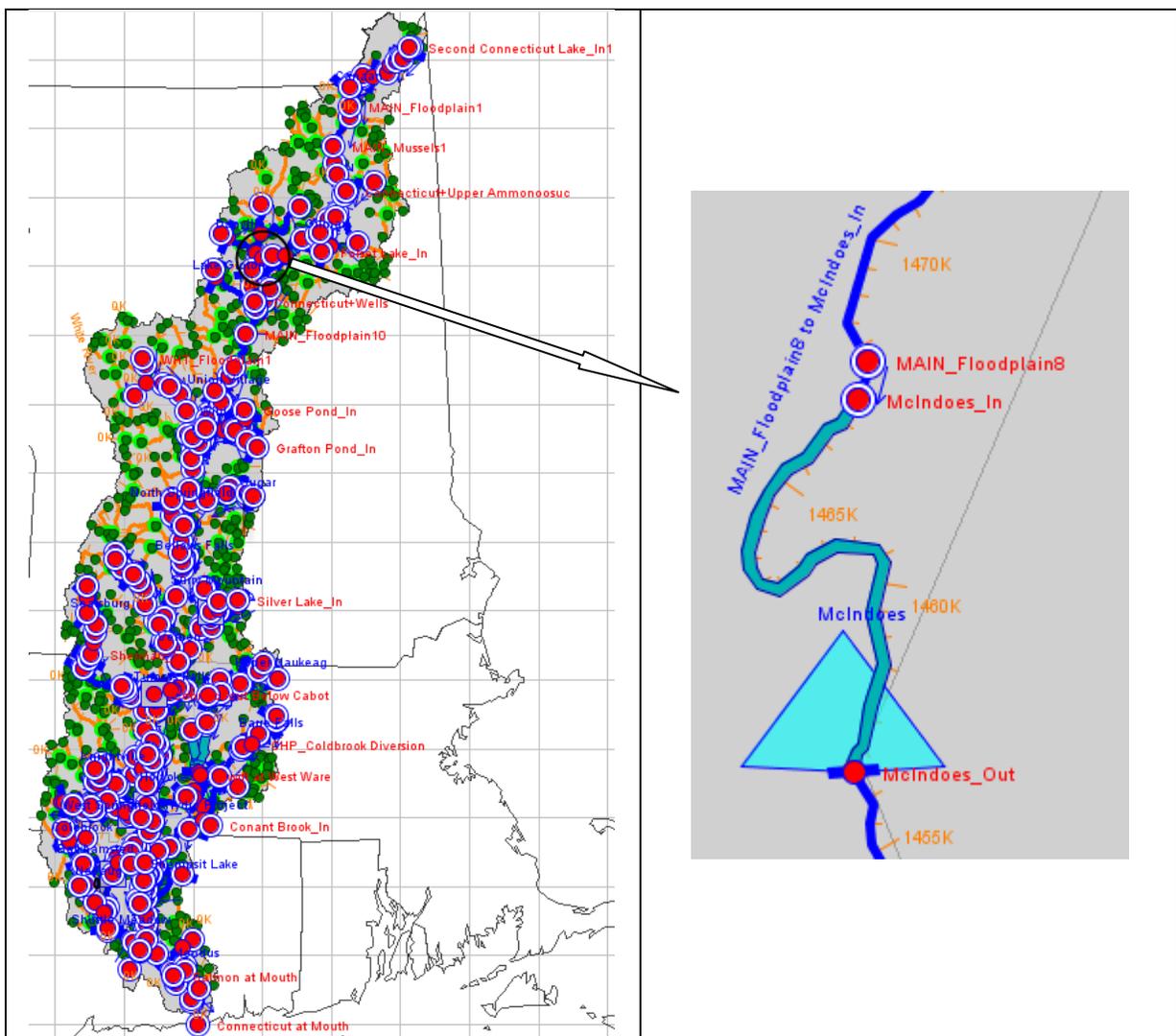


Figure 1: HEC-ResSim Map Display Showing Location of McIndoes dam



Figure 2: Photo of McIndoes Dam

## II. Physical Characteristics

The physical characteristics of the reservoir are separated between the Pool and the Dam in the HEC-ResSim model. The elevation-storage-area defines the pool as shown in Figure 3<sup>64</sup>. The dam consists of six types of outlets: (1) uncontrolled outlet, (2) controlled skimmer gate, (3) controlled tainter gate, (4) controlled needle flashboard, (5) controlled pin flashboard, (6) and power plant as shown in Figure 4.

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<sup>64</sup> Data provided by TransCanada

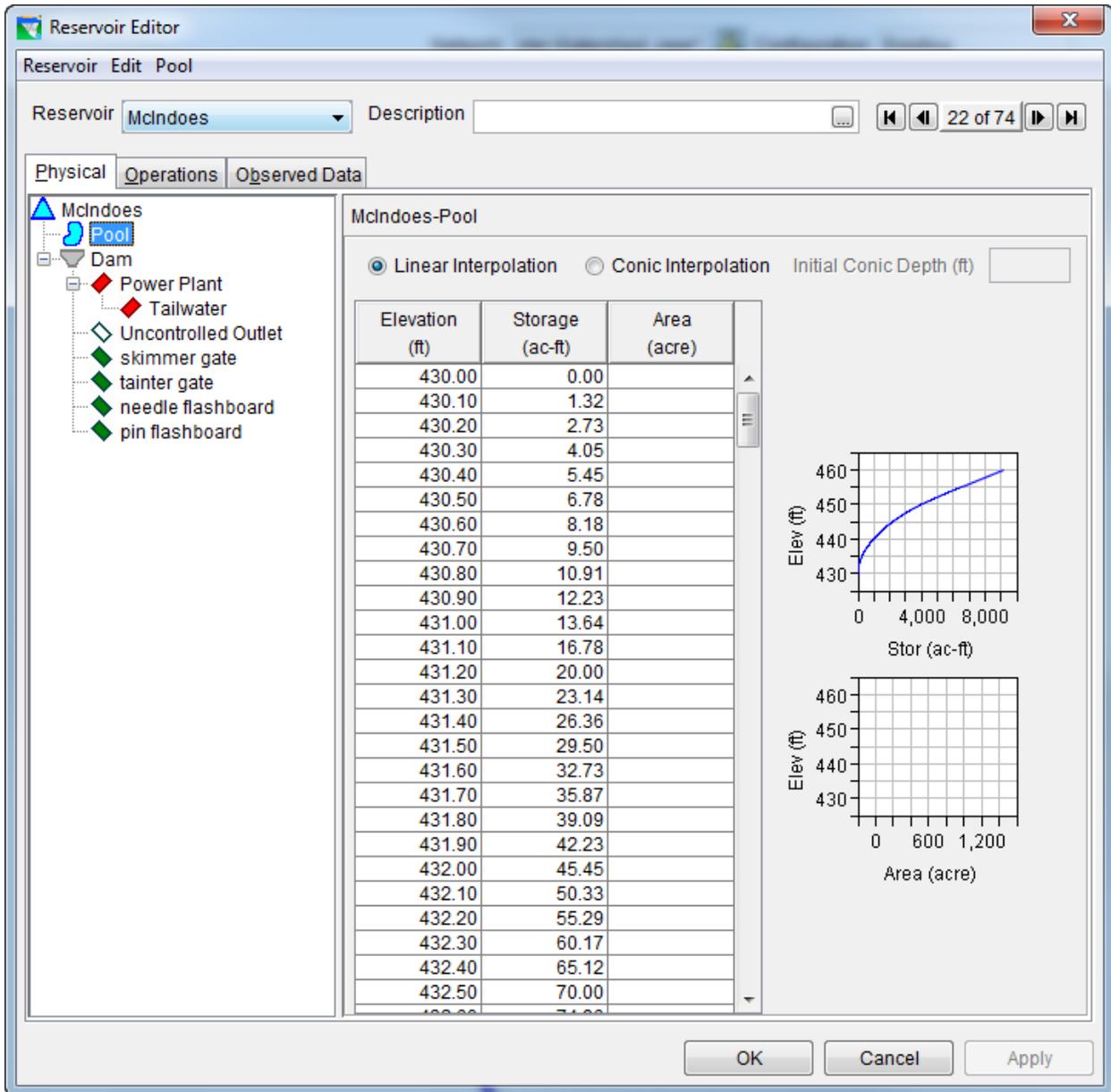


Figure 3: Reservoir Editor: Physical Tab -- Pool

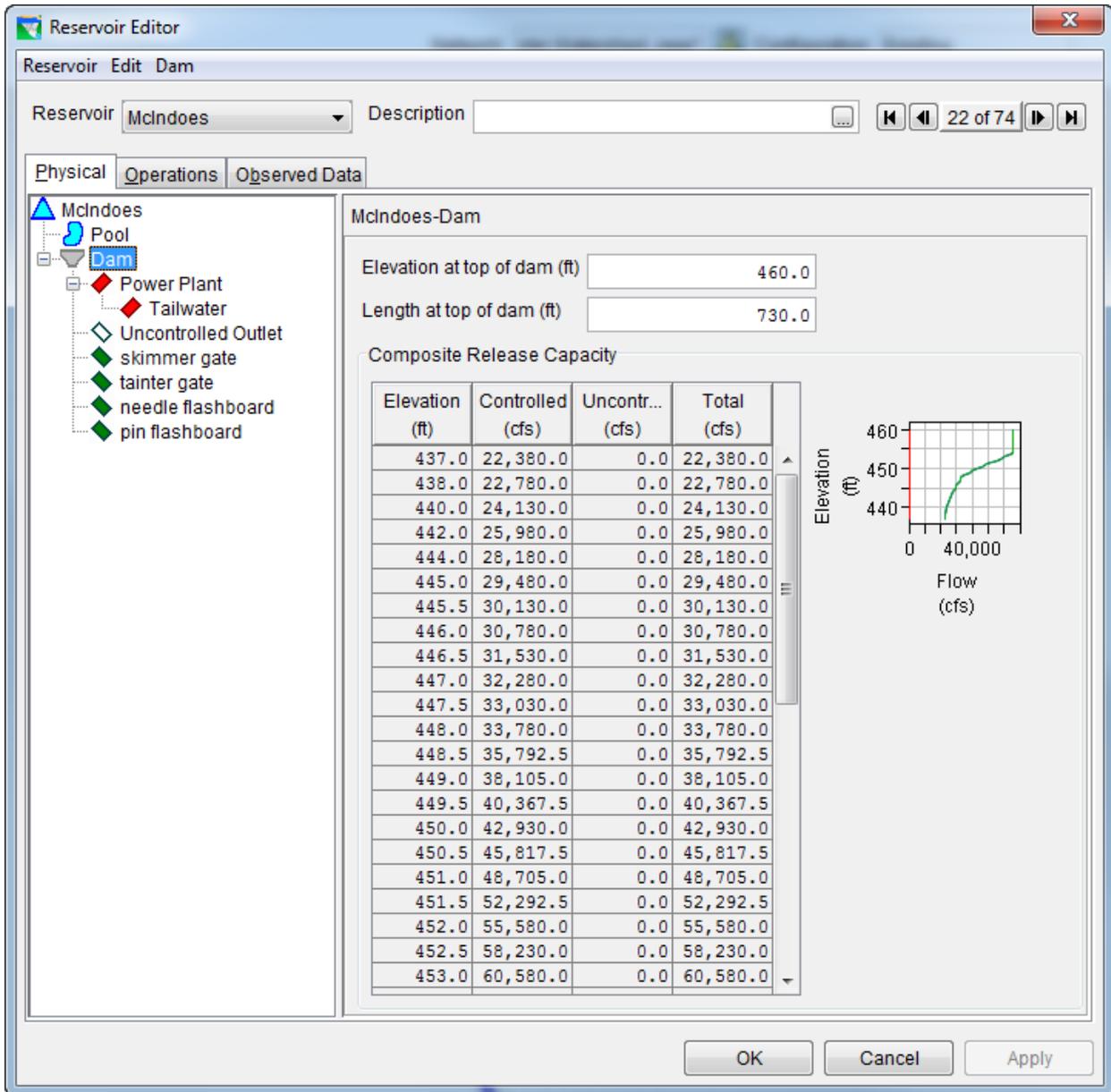


Figure 4: Reservoir Editor: Physical Tab -- Dam



## B. Rule Illustrations

Figure 6 shows a set of operational rules specified for each zone that reflects the operation set named Existing<sup>65</sup>.

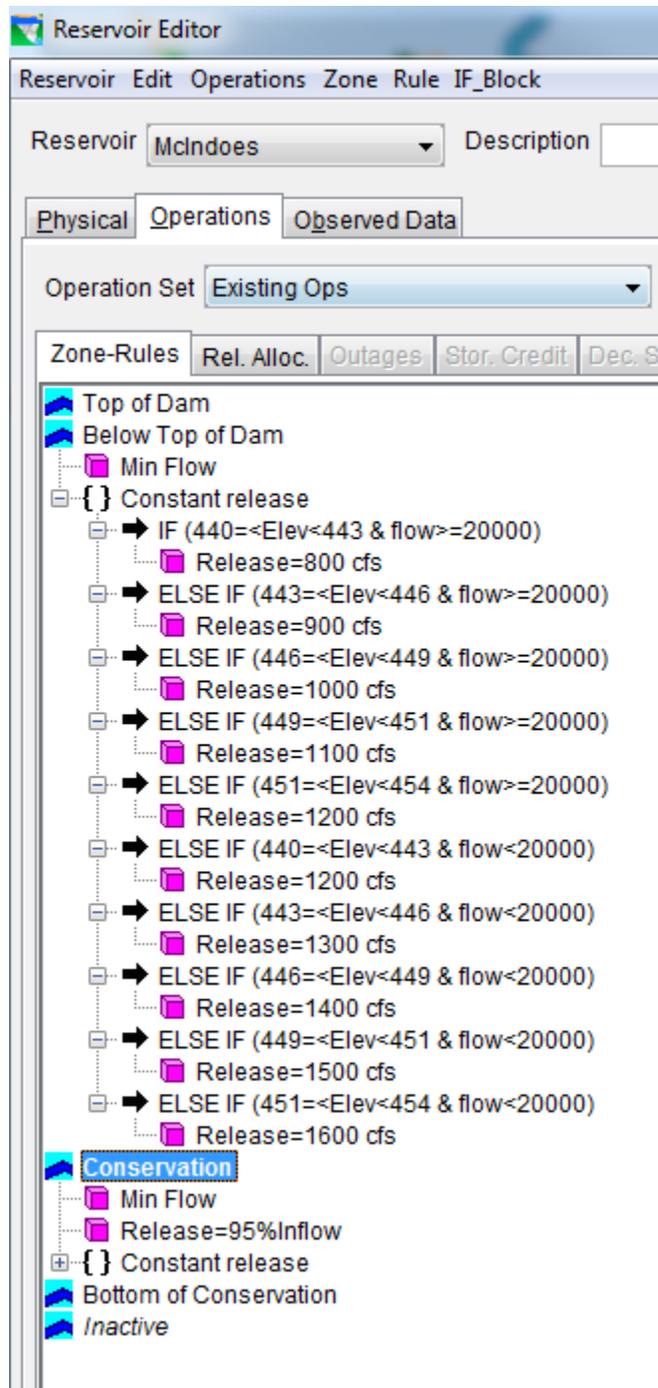


Figure 6: Reservoir Editor: Operations Tab – Existing Ops OpSet – Zones and Rules

<sup>65</sup> TransCanada. Connecticut River Operational Constraints. 2012.

Figure 7 shows a sequential release allocation approach specified for available outlets along Bellows Falls Dam. The available outlets are given an order of priority for release. The power plant gets the release first until it reaches release capacity. The skimmer gate gets the remainder of the release until it reaches capacity. Then the flow passes through tainter gate. After the capacity through the tainter gate is reached, the remainder of the release goes through the needle flashboard and pin flashboard, respectively.

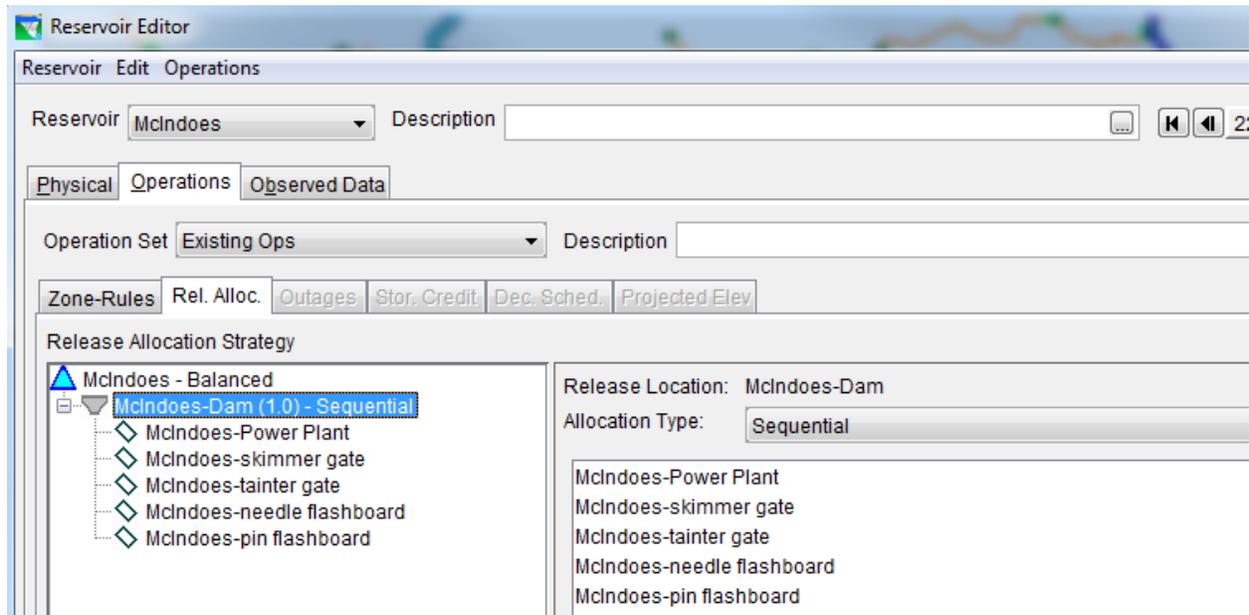


Figure 7: Reservoir Editor: Operations Tab – Existing OpSet – Release Allocation

## C. Rule Descriptions

### 1. Min Flow

Figure 8 shows the content of “Min Flow” rule. This rule represents the minimum allowable release from dam.

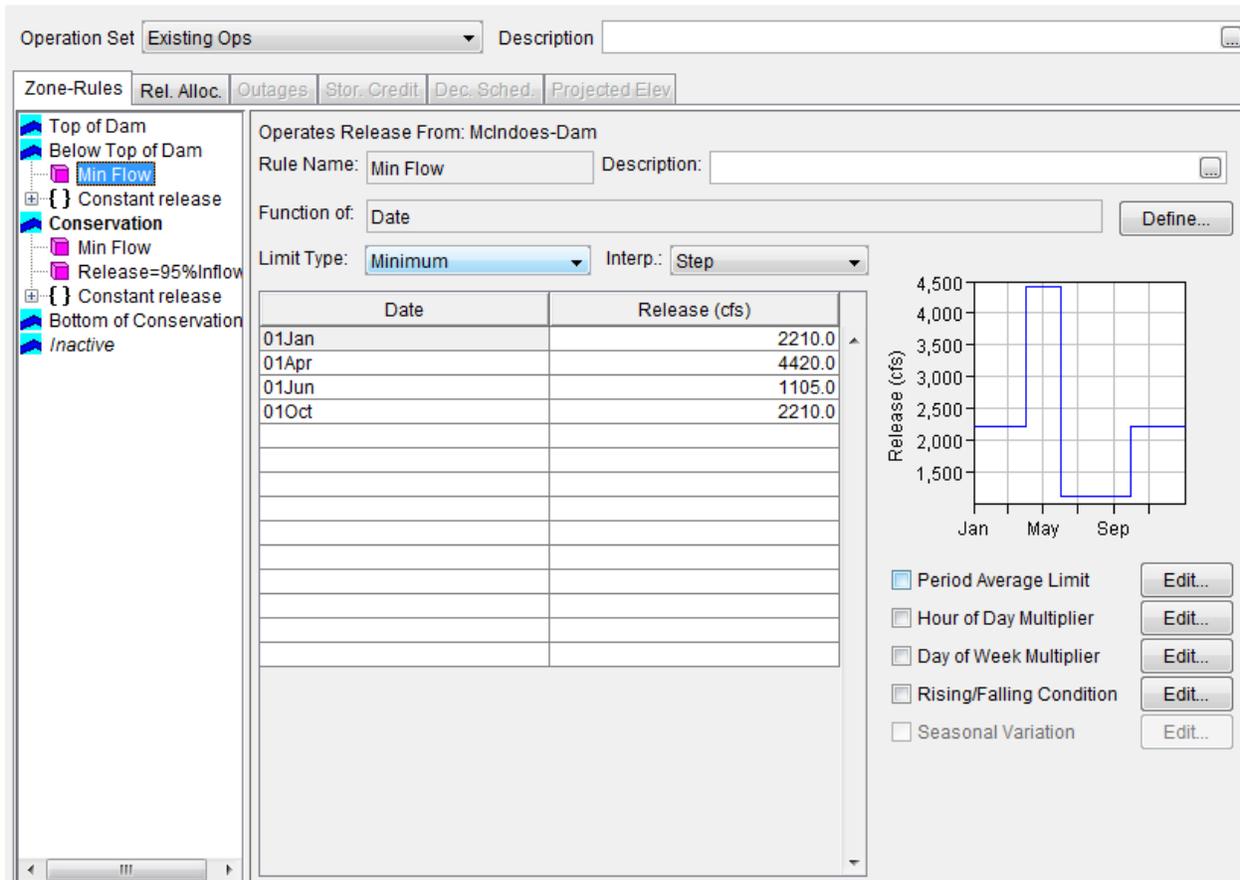


Figure 8: Reservoir Editor: Operations Tab – Existing Ops OpSet – Min Flow

## 2. Constant release

Figure 9 shows the content of “Constant release” rule. It shows the minimum allowable release for different combinations of Inflow and elevation.

The screenshot displays the 'Operations Tab' in the Reservoir Editor. The 'Operation Set' is 'Existing Ops'. The 'Zone-Rules' tab is active, showing a tree view on the left and a rule configuration panel on the right.

**Zone-Rules Tree View:**

- Top of Dam
- Below Top of Dam
  - Min Flow
  - Constant release** (selected)
  - IF (440=<Elev<443 & flow>=20000)
    - Release=800 cfs
  - ELSE IF (443=<Elev<446 & flow>=20000)
    - Release=900 cfs
  - ELSE IF (446=<Elev<449 & flow>=20000)
    - Release=1000 cfs
  - ELSE IF (449=<Elev<451 & flow>=20000)
    - Release=1100 cfs
  - ELSE IF (451=<Elev<454 & flow>=20000)
    - Release=1200 cfs
  - ELSE IF (440=<Elev<443 & flow<20000)
    - Release=1200 cfs
  - ELSE IF (443=<Elev<446 & flow<20000)
    - Release=1300 cfs
  - ELSE IF (446=<Elev<449 & flow<20000)
    - Release=1400 cfs
  - ELSE IF (449=<Elev<451 & flow<20000)
    - Release=1500 cfs
  - ELSE IF (451=<Elev<454 & flow<20000)
    - Release=1600 cfs
- Conservation
  - Min Flow
  - Release=95%Inflow
  - Constant release
  - Bottom of Conservation
  - Inactive

**Operates Release From: McIndoes-Dam**

Name: Constant release Description:

Type	Name	Description
IF	440=<Elev<443 & flow>=20000	
ELSE IF	443=<Elev<446 & flow>=20000	
ELSE IF	446=<Elev<449 & flow>=20000	
ELSE IF	449=<Elev<451 & flow>=20000	
ELSE IF	451=<Elev<454 & flow>=20000	
ELSE IF	440=<Elev<443 & flow<20000	
ELSE IF	443=<Elev<446 & flow<20000	
ELSE IF	446=<Elev<449 & flow<20000	
ELSE IF	449=<Elev<451 & flow<20000	
ELSE IF	451=<Elev<454 & flow<20000	

Figure 9: Reservoir Editor: Operations Tab – Existing Ops OpSet – Constant release

### 3. Release=95% Inflow

Figure 10 shows the content of “Release=95% Inflow” rule. It releases 95% of Inflow as a minimum release from power plant as per the run-of-river modeling strategy.

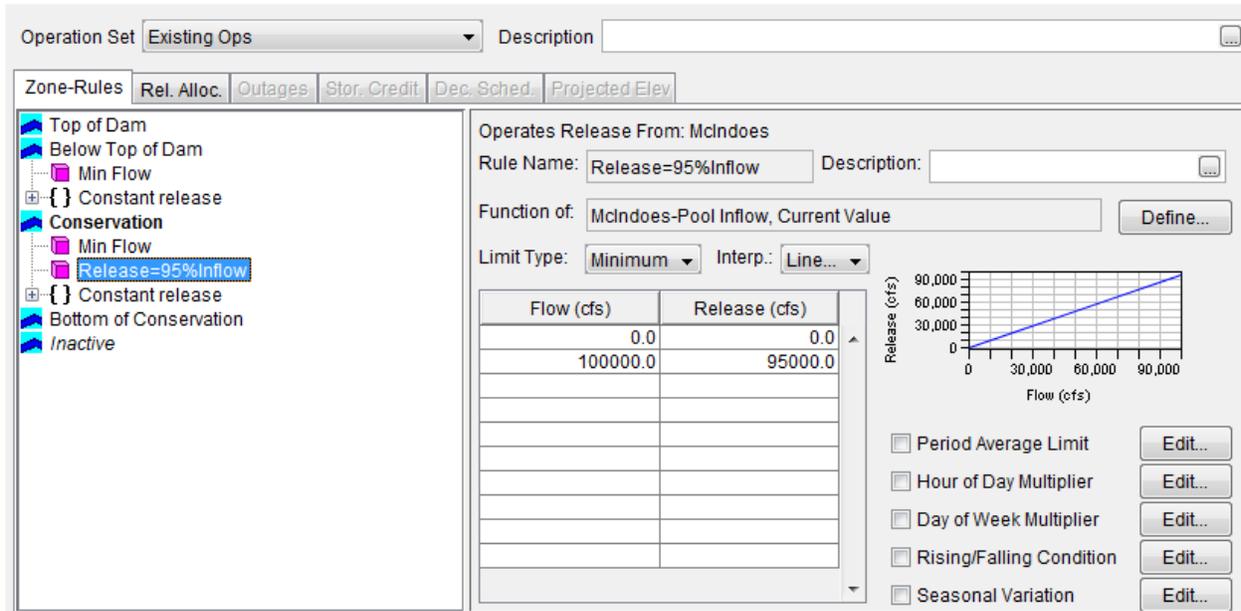


Figure 10: Reservoir Editor: Operations Tab – Existing Ops OpSet – Release=95% Inflow

# Moodus

## I. Overview

Moodus reservoir and dam is located on the Moodus River in East Haddam, CT. The dam is owned by the State of Connecticut. It is primarily used for recreation and some local flood protection.

Figure 1 shows the location of Moodus reservoir as it is represented in the HEC-ResSim model. Figure 2 shows a photo of Moodus reservoir.

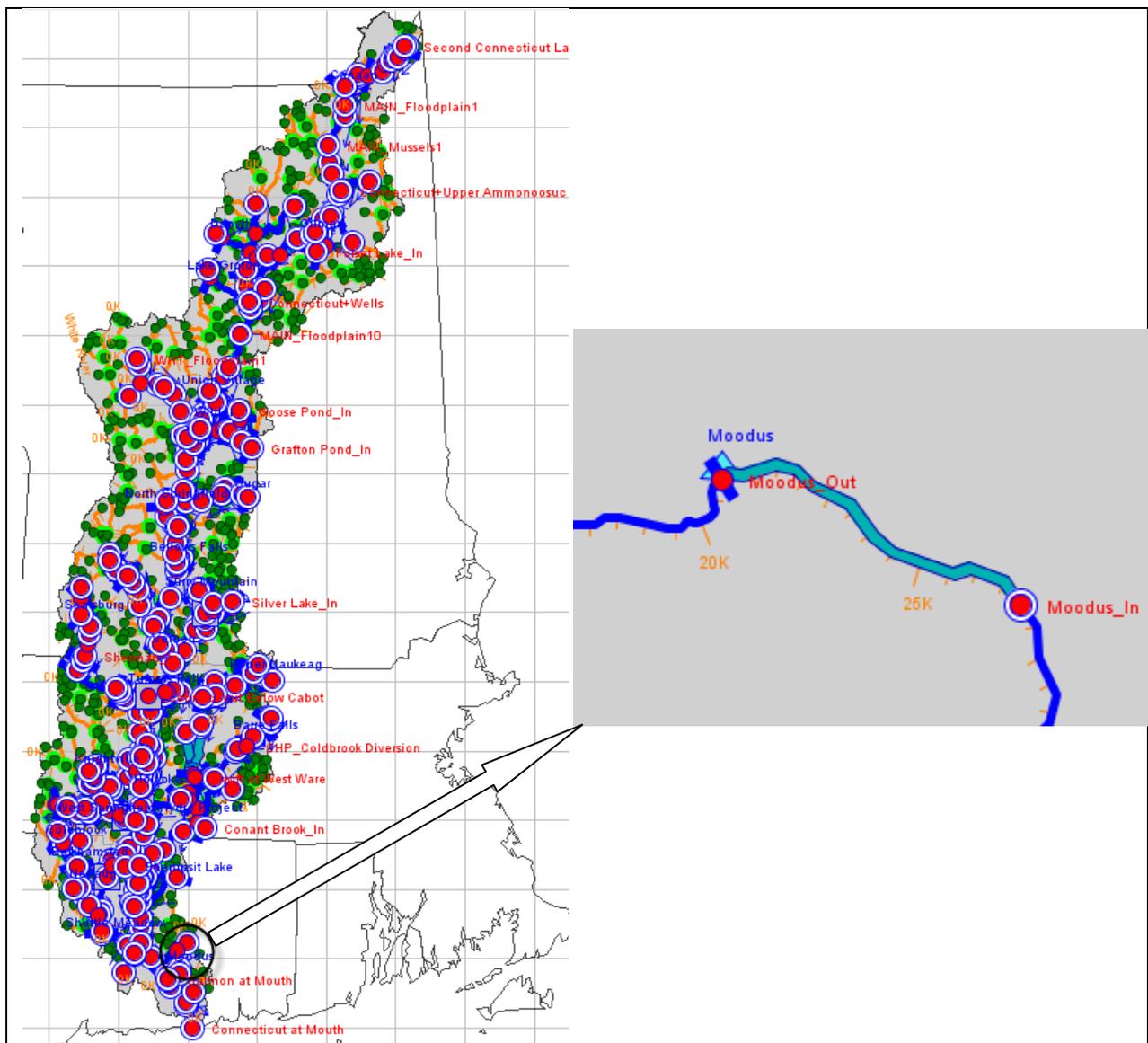


Figure 1: HEC-ResSim Map Display Showing Location of Moodus



**Figure 2: Photo of Moodus reservoir**

## **II. Physical Characteristics**

The physical characteristics of the reservoir are separated between the Pool and the Dam in the HEC-ResSim model. The elevation-storage-area defines the pool as shown in Figure 3<sup>66</sup>. The dam consists of an uncontrolled spillway and outlet as shown in Figure 4<sup>67</sup>.

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<sup>66</sup> Provided by the operators of Moodus

<sup>67</sup> WMC Consulting Engineers. Moodus Reservoir Dam. Newington, CT 2006.

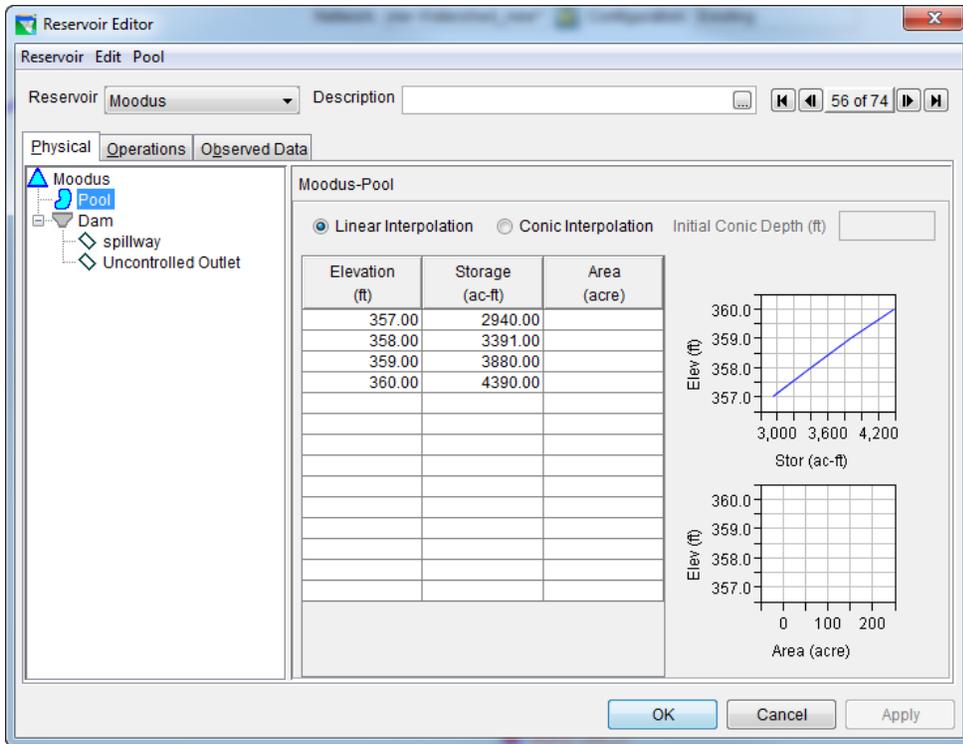


Figure 3: Reservoir Editor: Physical Tab -- Pool

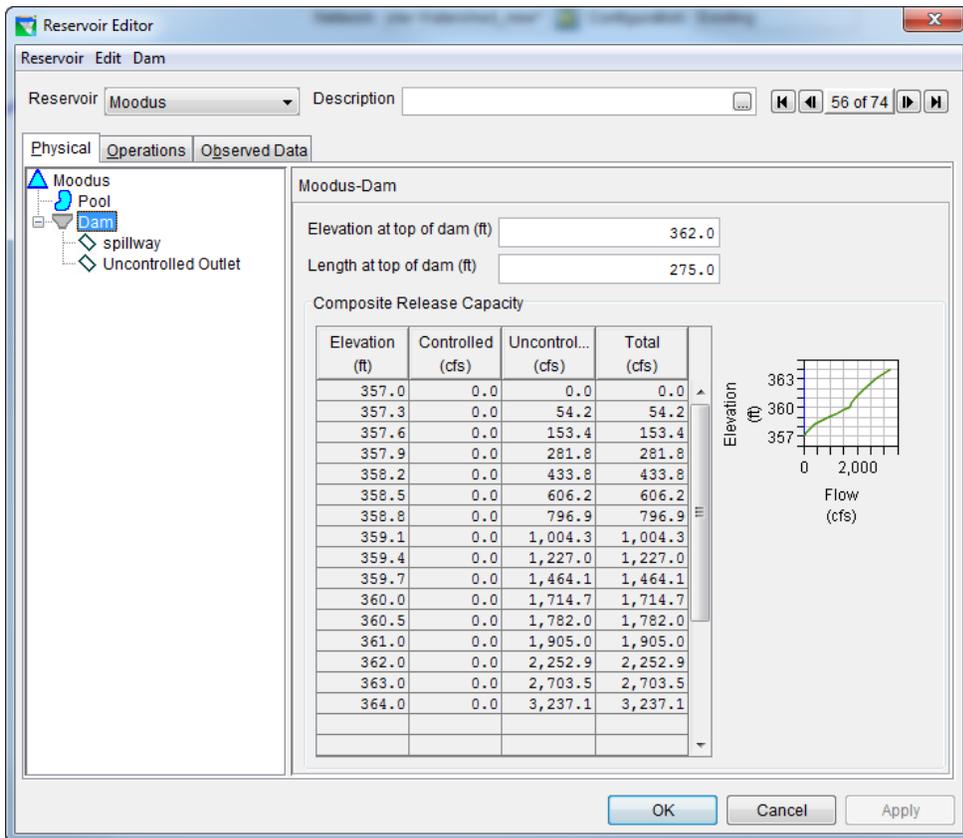


Figure 3 Reservoir Editor: Physical Tab -- Dam



# Moore

## I. Overview

Moore dam is located on the mainstem Connecticut River in the towns of Littleton, NH, and Waterford, VT. It is owned and operated by TransCanada Hydro Northeast Inc. as part of the 15 Mile Falls project for hydropower generation on a peaking, seasonal storage basis.

Figure 1 shows the location of Moore dam as it is represented in the HEC-ResSim model, and Figure 2 shows a photo from Moore dam.

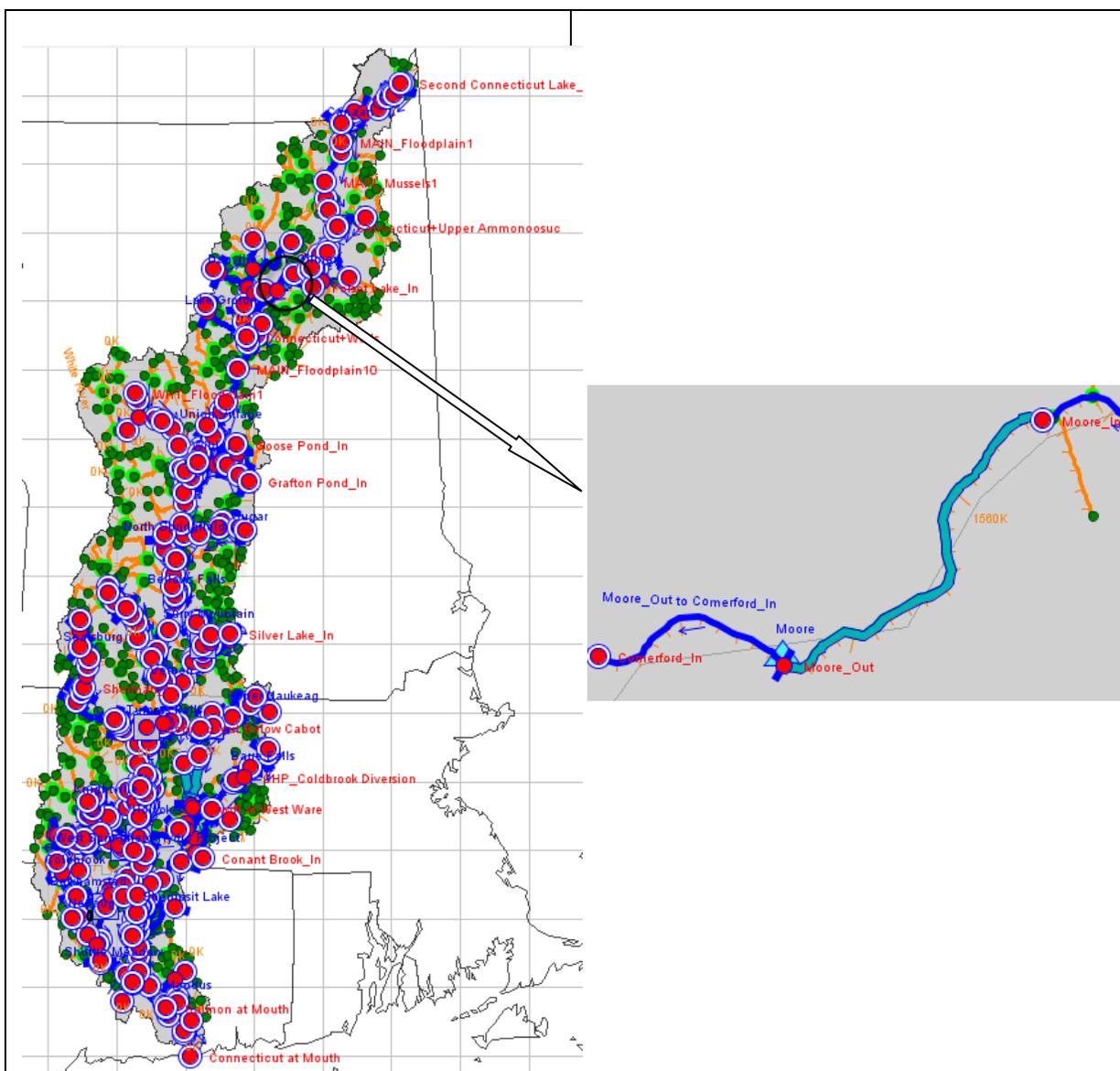


Figure 1 HEC-ResSim Map Display Showing Location of Moore



Figure 2: Photo of Moore dam

## II. Physical Characteristics

The physical characteristics of the reservoir are separated between the Pool and the Dam in the HEC-ResSim model. The elevation-storage-area defines the pool as shown in Figure 3<sup>68</sup>. The dam consists of four types of outlets: (1) controlled skimmer gate, (2) controlled tainter gate, (3) uncontrolled stanchion Bays, and (4) power plant as shown in Figure 4.

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<sup>68</sup> Data provided by TransCanada

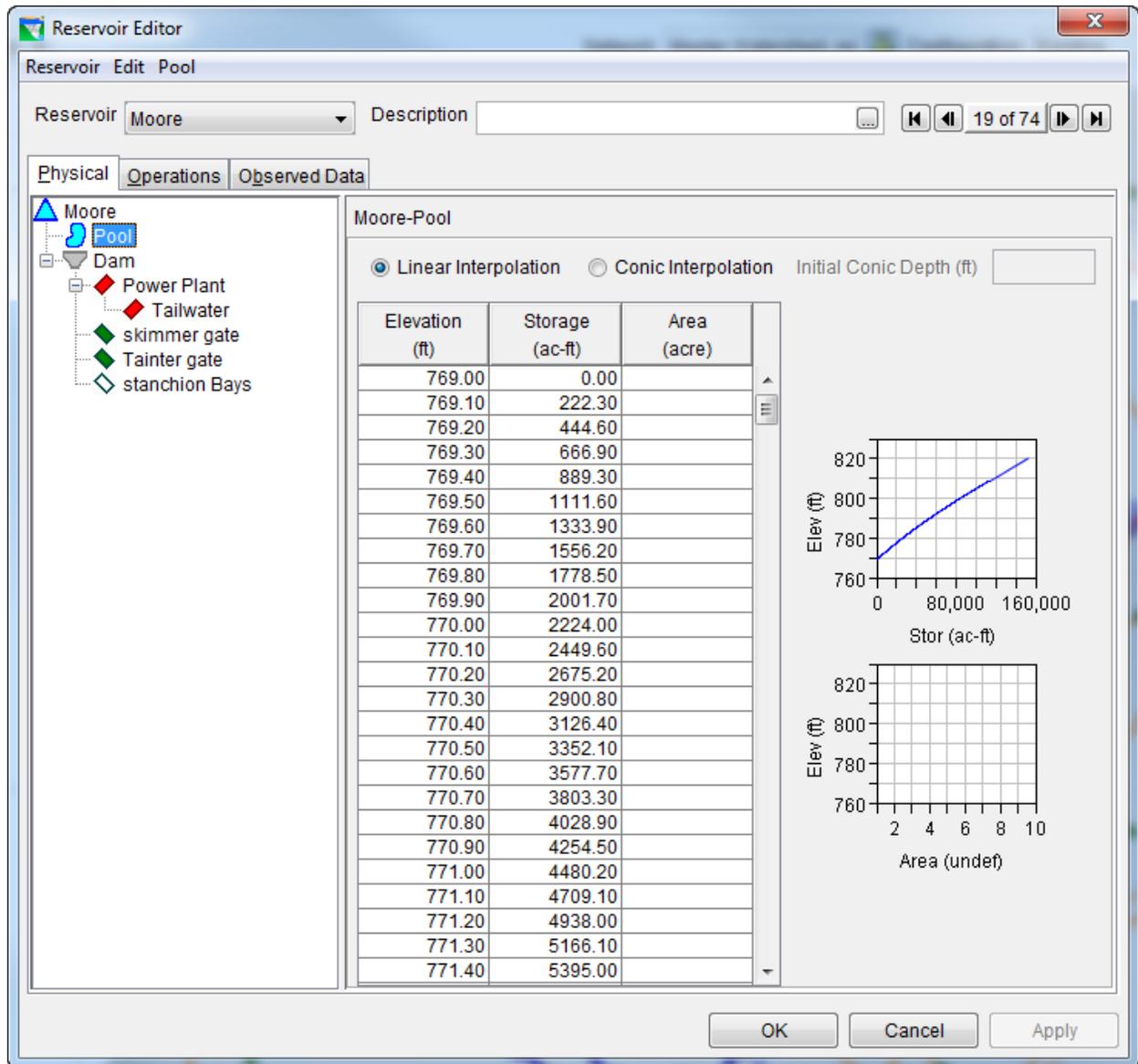


Figure 3: Reservoir Editor: Physical Tab -- Pool

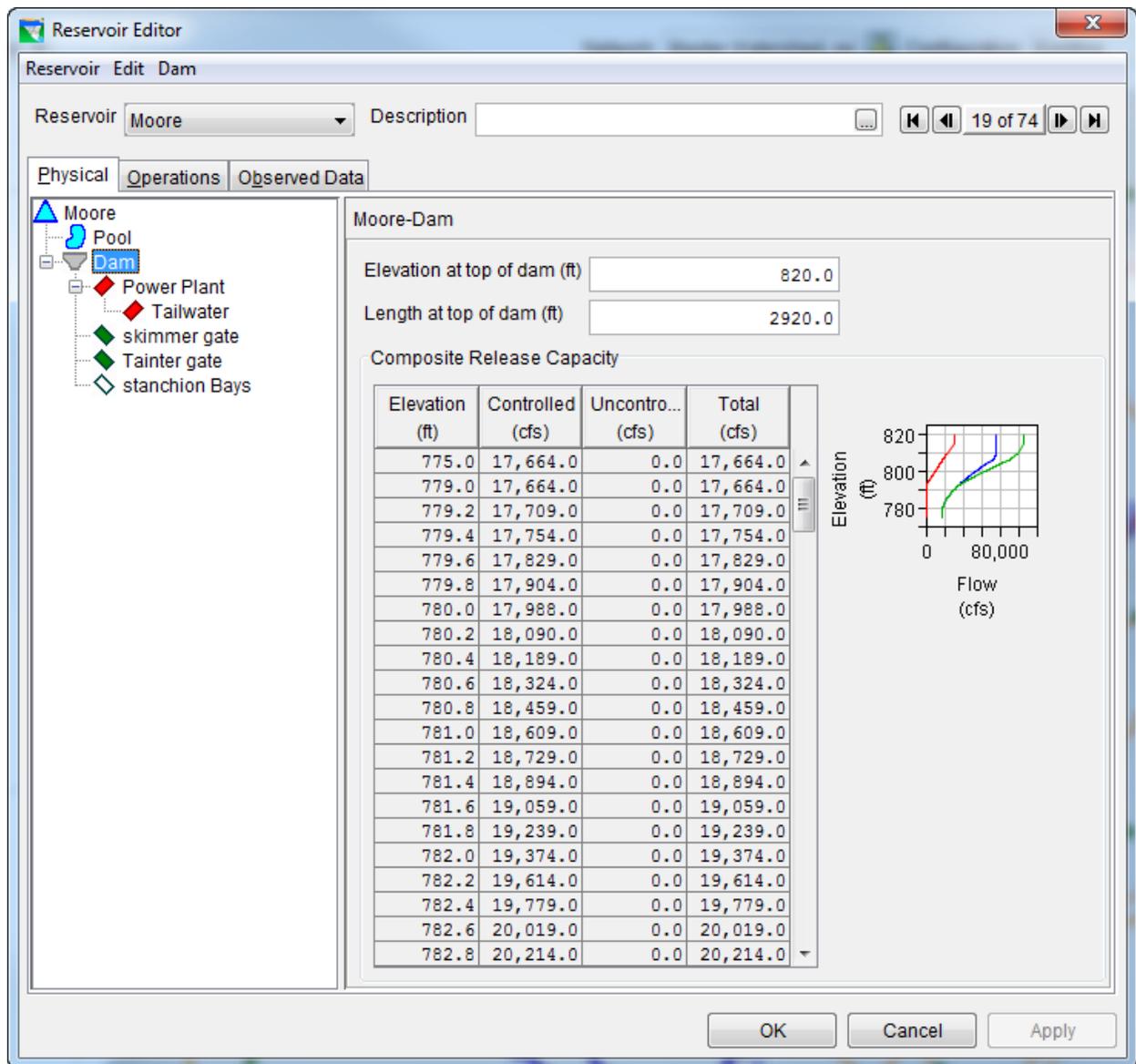


Figure 4: Reservoir Editor: Physical Tab -- Dam

### III. Operations

#### A. Operation Set

Zones are used to define the operational storage in the reservoir to determine the reservoir release through analysis of the rules contained within each zone. Figure 5 shows the definition of Moor’s “Existing” operational zones, which consist of zones of Top of dam (820 ft), Below Top of Dam (809 ft), Conservation (779.8-806.5 ft), and Inactive zone (769 ft). The Conservation Pool Elevation curve was created from 10 years of weekly average pool elevation<sup>1</sup>.

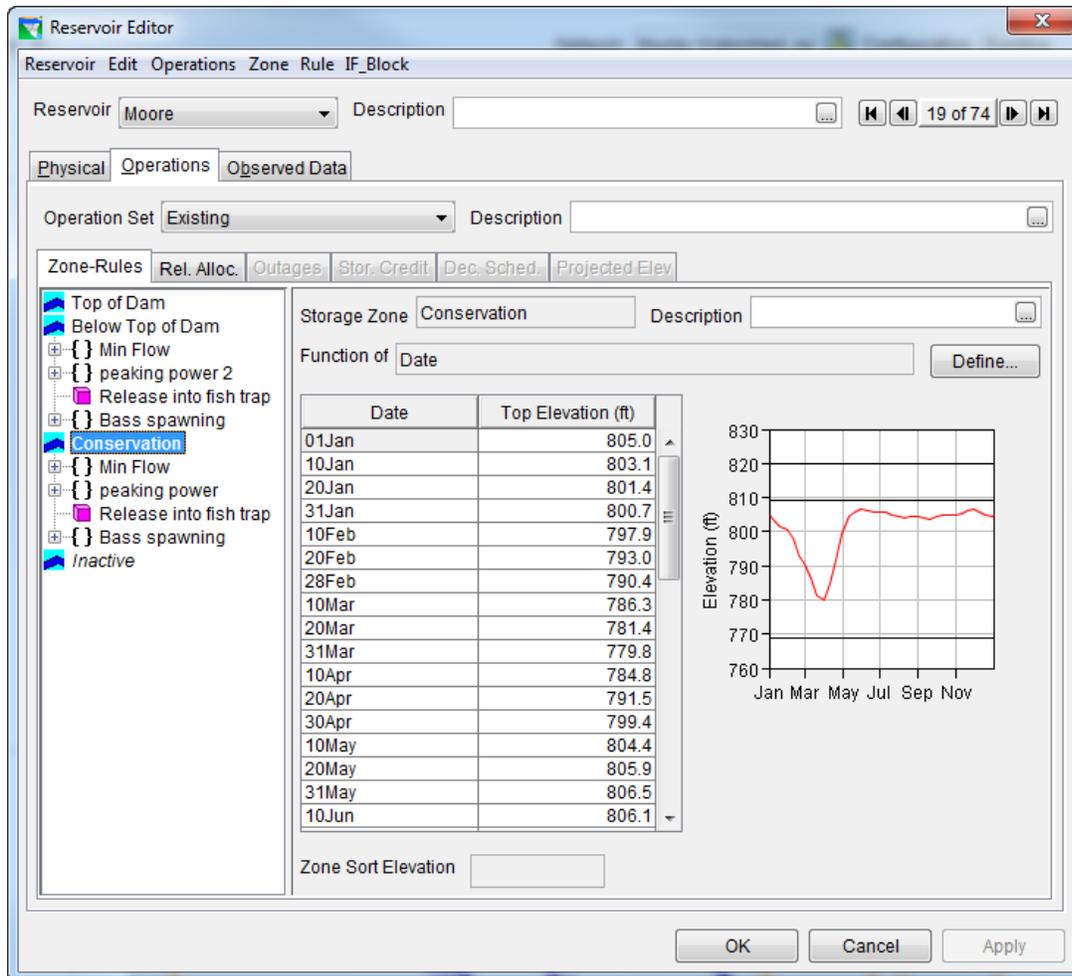


Figure 5: Reservoir Editor: Operations Tab –Existing OpSet – Guide Curve

Figure 6 shows a sequential release allocation approach specified for available outlets along Harriman Dam. The available outlets are given an order of priority for release. The power plant gets the release first until it reaches release capacity. The skimmer gate and tainter gate gets the remainder of the release, respectively.

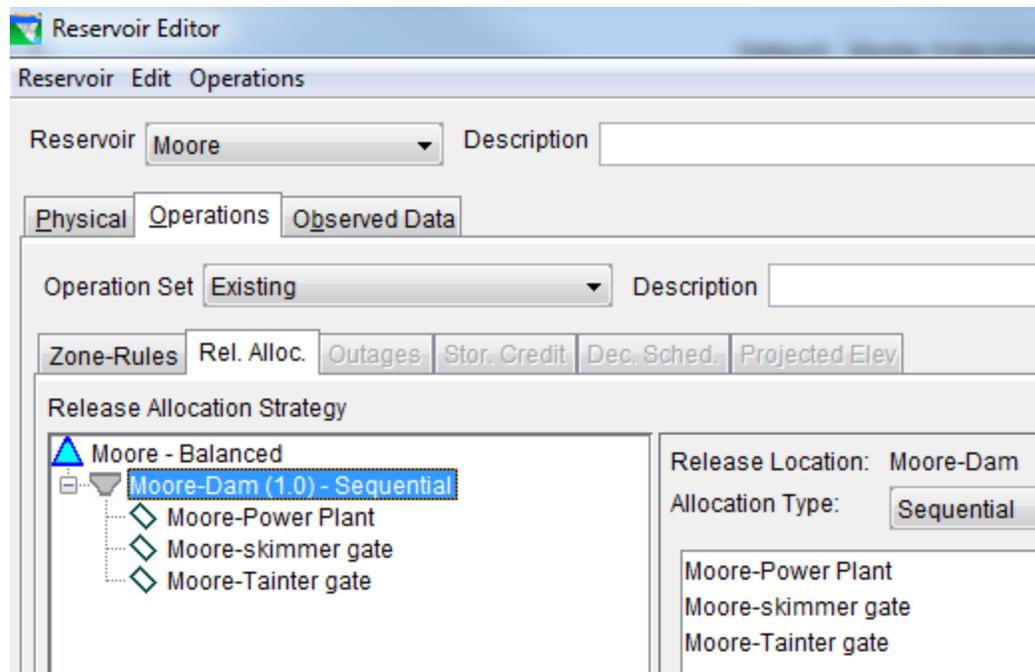


Figure 6: Reservoir Editor: Operations Tab – Existing Ops OpSet – Release Allocation

## B. Rule Illustrations

Figure 7 shows a set of operational rules specified for each zone that reflects the operation set named Existing<sup>69</sup>.

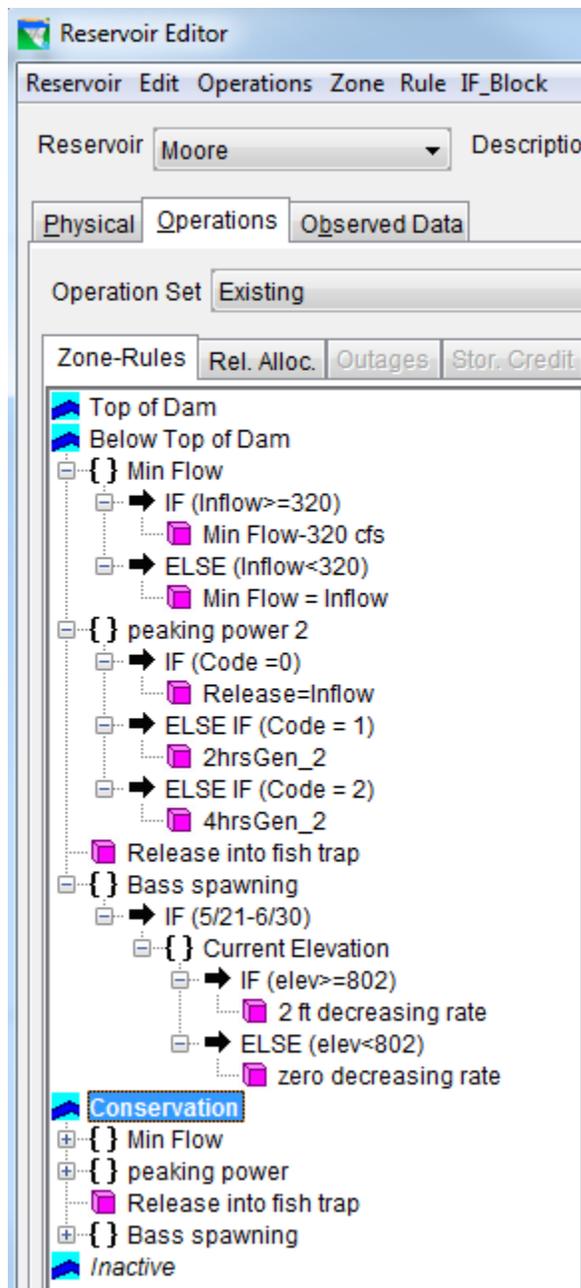


Figure 7: Reservoir Editor: Operations Tab – Existing Ops OpSet – Zones and Rules

<sup>69</sup> TransCanada. Connecticut River Operational Constraints. 2012.

## C. Rule Descriptions

### 1. Min flow

Figure 8 shows the content of “Min Flow” rule. This rule sets the minimum flow to 320 cfs for the inflows greater than 320 cfs and inflow for the inflows less than 320 cfs.

The screenshot displays the configuration of a "Min Flow" rule in a software interface, organized into four distinct panels.

**Panel 1 (Top):** Shows the rule's general information. The "Operation Set" is "Existing". The rule name is "Min Flow". A table lists the rule's conditions:

Type	Name	Description
IF	Inflow >= 320	
ELSE	Inflow < 320	

**Panel 2:** Shows the configuration for the "IF" condition. It is titled "Operates Release From: Moore-Dam". The "IF Conditional" is "Inflow >= 320". A table below shows the conditional logic:

Value1	Value2
Moore-Pool:Net Inflow	>= 320

**Panel 3:** Shows the configuration for the "Min Flow-320 cfs" rule. It is titled "Operates Release From: Moore-Dam". The "Rule Name" is "Min Flow-320 cfs". The "Function of" is "Date". The "Limit Type" is "Minim..." and the "Interp." is "Lin...". A table shows the release schedule:

Date	Release (cfs)
01Jan	320.0

To the right of the table is a graph showing "Release (cfs)" on the y-axis (ranging from 316 to 324) and months on the x-axis (Jan, Mar, May, Jul, Sep, Nov). A horizontal blue line is drawn at 320 cfs.

**Panel 4 (Bottom):** Shows the configuration for the "ELSE" condition. It is titled "Operates Release From: Moore-Dam". The "ELSE Conditional" is "Inflow < 320".

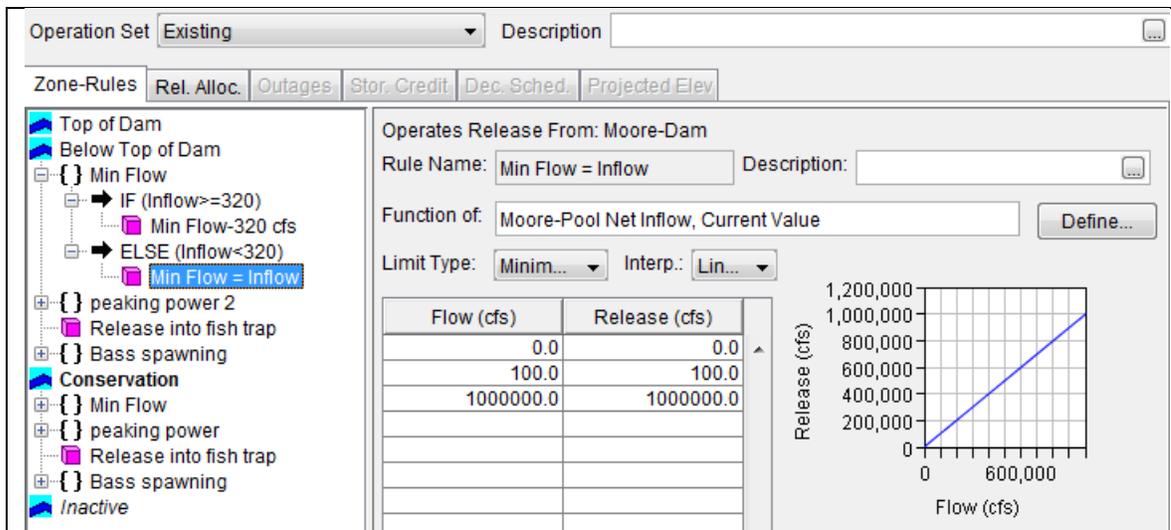
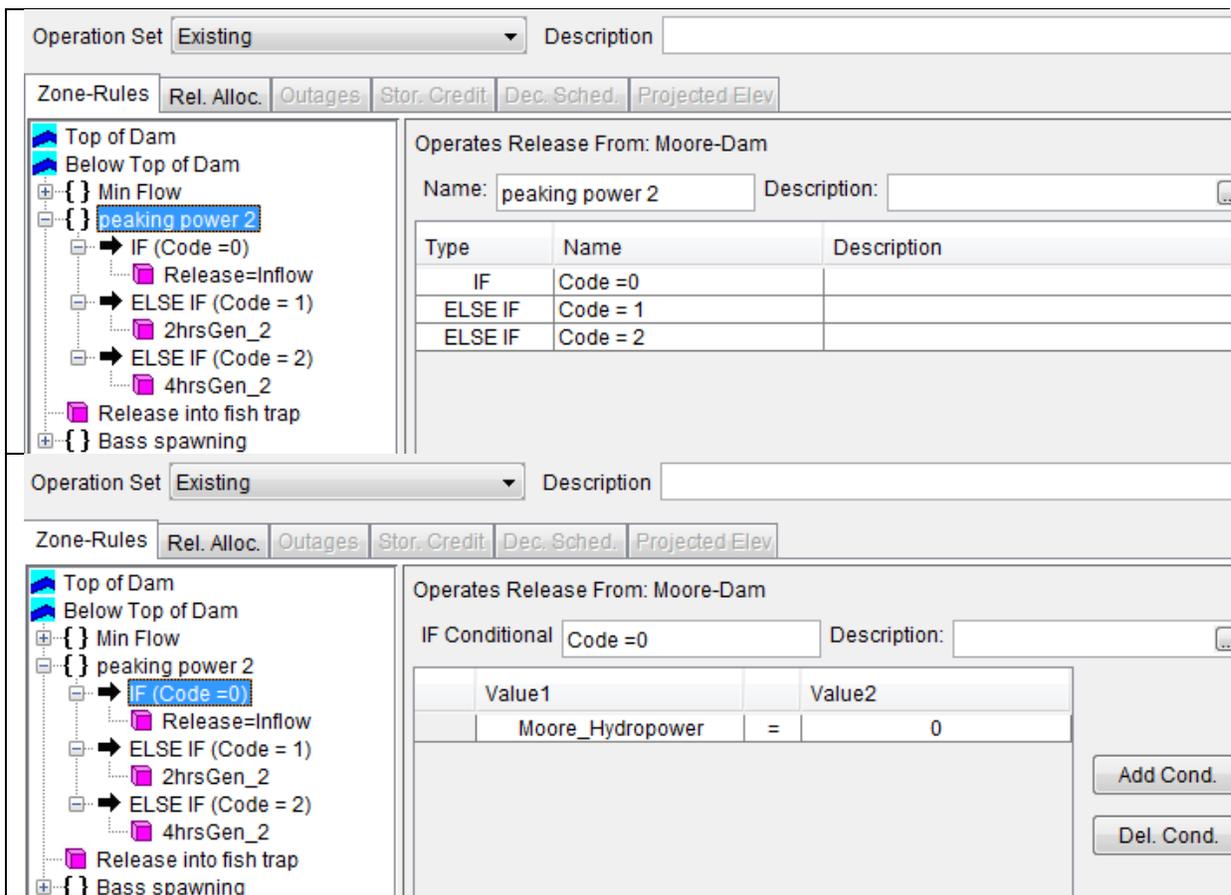


Figure 8: Reservoir Editor: Operations Tab – Existing OpSet – Min Flow

## 2. Peaking power 2

This rule represents the peaking power strategy applied for Moore reservoir. The content of the rule is shown in Figure 9.



Operation Set Existing Description

Zone-Rules Rel. Alloc. Outages Stor. Credit Dec. Sched. Projected Elev

Operates Release From: Moore-Power Plant

Rule Name: Release=Inflow Description: ...

Function of: Moore-Pool Net Inflow, Current Value Define...

Limit Type: Minim... Interp.: Lin...

Flow (cfs)	Release (cfs)
0.0	0.0
100000.0	100000.0

Reservoir Moore Description ... 19 of 74

Physical Operations Observed Data

Operation Set Existing Description

Zone-Rules Rel. Alloc. Outages Stor. Credit Dec. Sched. Projected Elev

Operates Release From: Moore-Power Plant

ELSE IF Conditional Code = 1 Description: ...

Value1	Value2
Moore_Hydropower	= 1

Add Cond. Del. Cond.





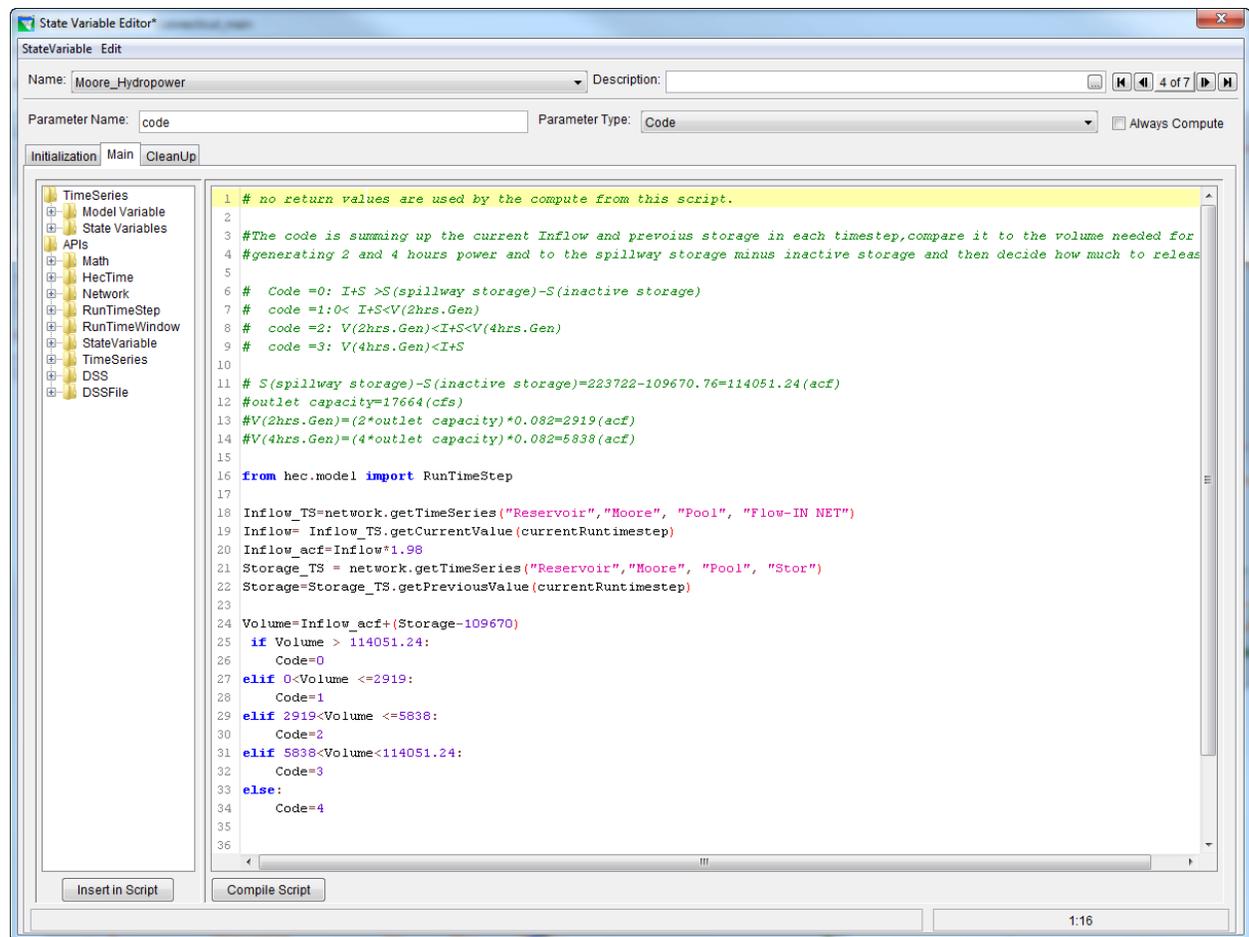


Figure 10: State Variable Editor: Moor\_Volume

### 3. Release into fish trap

Figure 11 shows the content of “Release into fish trap” rule. This rule represents a 500 cfs release from Apr1-Jun15.

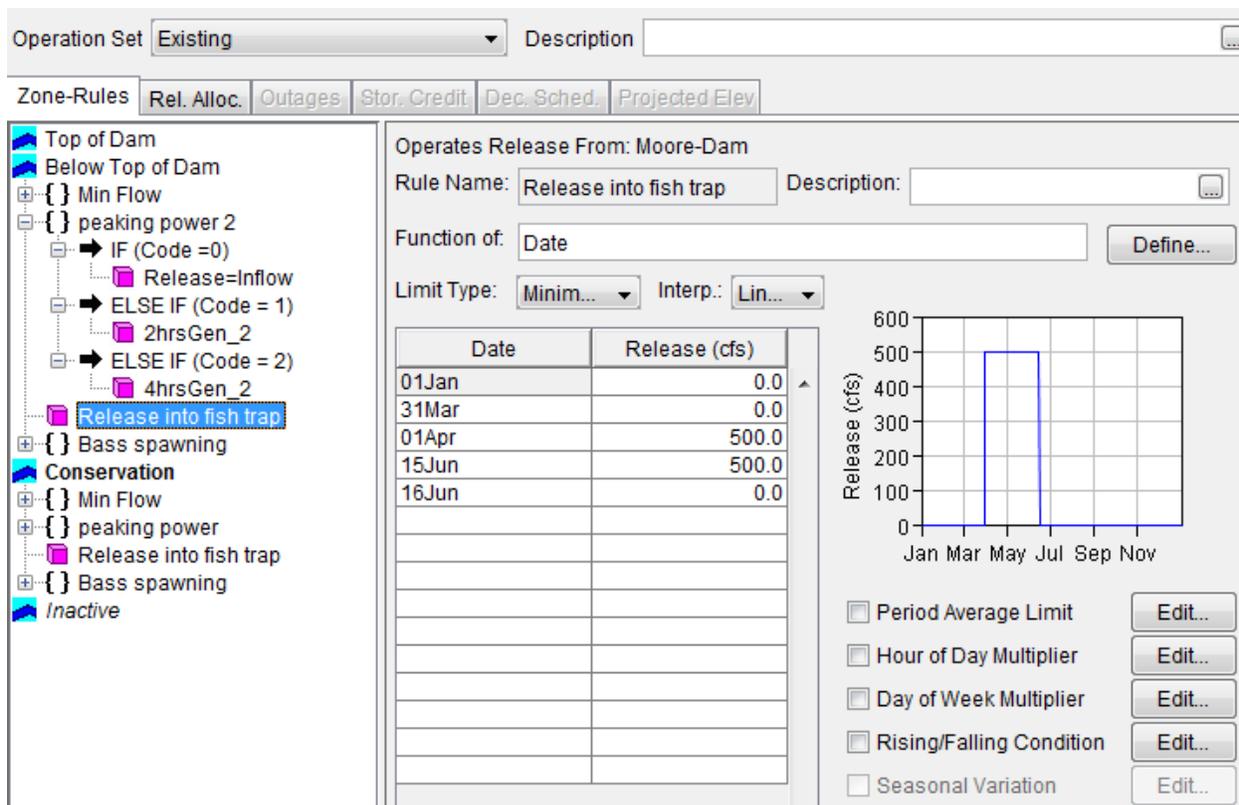


Figure 11: Reservoir Editor: Operations Tab – Existing Ops OpSet – Release into fish trap

#### 4. Bass spawning

Figure 12 shows the content of “Bass spawning” rule. It shows a decreasing maximum rate of elevation change of 2 ft/hr when the pool elevation is greater than 802 ft and a decreasing maximum rate of elevation change of zero ft/hr when the pool elevation is less than 802 ft during May21-Jun30.

The figure displays three sequential screenshots of a software interface for configuring a rule. The rule is named "Bass spawning" and is associated with the "Existing" operation set.

**Top Screenshot:** Shows the rule tree on the left with "Bass spawning" selected. The right pane shows "Operates Release From: Moore" and "IF Conditional" logic. The logic table is as follows:

	Value1		Value2
	Current Time Step	>=	05May
AND	Current Time Step	<=	30Jun

**Middle Screenshot:** Shows the rule tree with "Current Elevation" selected. The right pane shows "Operates Release From: Moore" and "Name: Current Elevation". The logic table is as follows:

Type	Name	Description
IF	elev>=802	
ELSE	elev<802	

**Bottom Screenshot:** Shows the rule tree with "IF (elev>=802)" selected. The right pane shows "Operates Release From: Moore" and "IF Conditional" logic. The logic table is as follows:

	Value1		Value2
	Moore-Pool:Elevation	>=	802

The figure displays three sequential screenshots of the Reservoir Editor's Operations Tab for an Existing OpSet, specifically for the 'Bass spawning' rule. Each screenshot shows a tree view on the left and configuration options on the right.

- Top Screenshot:** The tree view shows the 'Bass spawning' rule expanded to 'IF (5/21-6/30)' > 'Current Elevation' > 'IF (elev>=802)'. The configuration on the right shows 'Operates Release From: Moore', 'Elevation Rate of Change Limit' set to '2 ft decreasing rate', 'Function Of: Constant', 'Type: Decreasing', and 'Max Rate of Change (ft/hr)' set to '2.0'.
- Middle Screenshot:** The tree view shows the 'Bass spawning' rule expanded to 'IF (5/21-6/30)' > 'Current Elevation' > 'ELSE (elev<802)'. The configuration on the right shows 'Operates Release From: Moore' and 'ELSE Conditional' set to 'elev<802'.
- Bottom Screenshot:** The tree view shows the 'Bass spawning' rule expanded to 'IF (5/21-6/30)' > 'Current Elevation' > 'ELSE (elev<802)'. The configuration on the right shows 'Operates Release From: Moore', 'Elevation Rate of Change Limit' set to 'zero decreasing rate', 'Function Of: Constant', 'Type: Decreasing', and 'Max Rate of Change (ft/hr)' set to '0.0'.

Figure 12: Reservoir Editor: Operations Tab – Existing OpSet – Bass spawning

# Nepaug

## I. Overview

Nepaug dam is located in the town of New Hartford, CT on the Nepaug River that feeds into the Farmington River. It is owned and operated by the The Metropolitan District of Hartford, Connecticut (MDC) and is used for water supply for the City of Hartford as well as the City of New Britain.

Figure 1 shows the location of Nepaug Dam as it is represented in the HEC-ResSim model. Figure 2 shows a photo of Nepaug Dam.

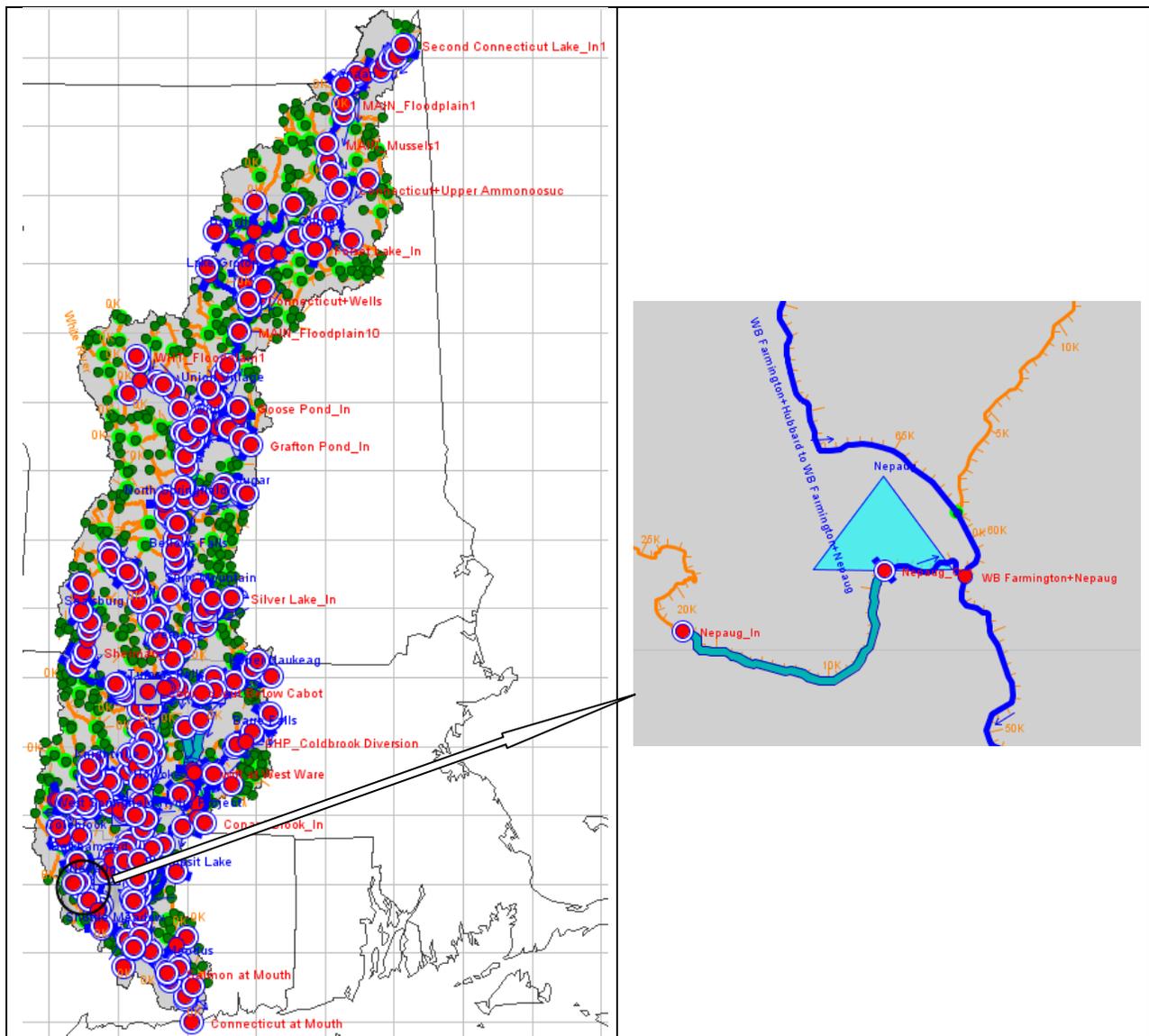


Figure 1: HEC-ResSim Map Display Showing Location of Nepaug



Figure 2: Photo of Nepaug Dam

## II. Physical Characteristics

The physical characteristics of the reservoir are separated between the Pool and the Dam in the HEC-ResSim model. The elevation-storage-area defines the pool as shown in Figure 3<sup>70</sup>. The dam consists of an uncontrolled outlet as shown in Figure 4<sup>71</sup>.

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<sup>70</sup> MDC 1999.

<sup>71</sup> Data provided by UMASS

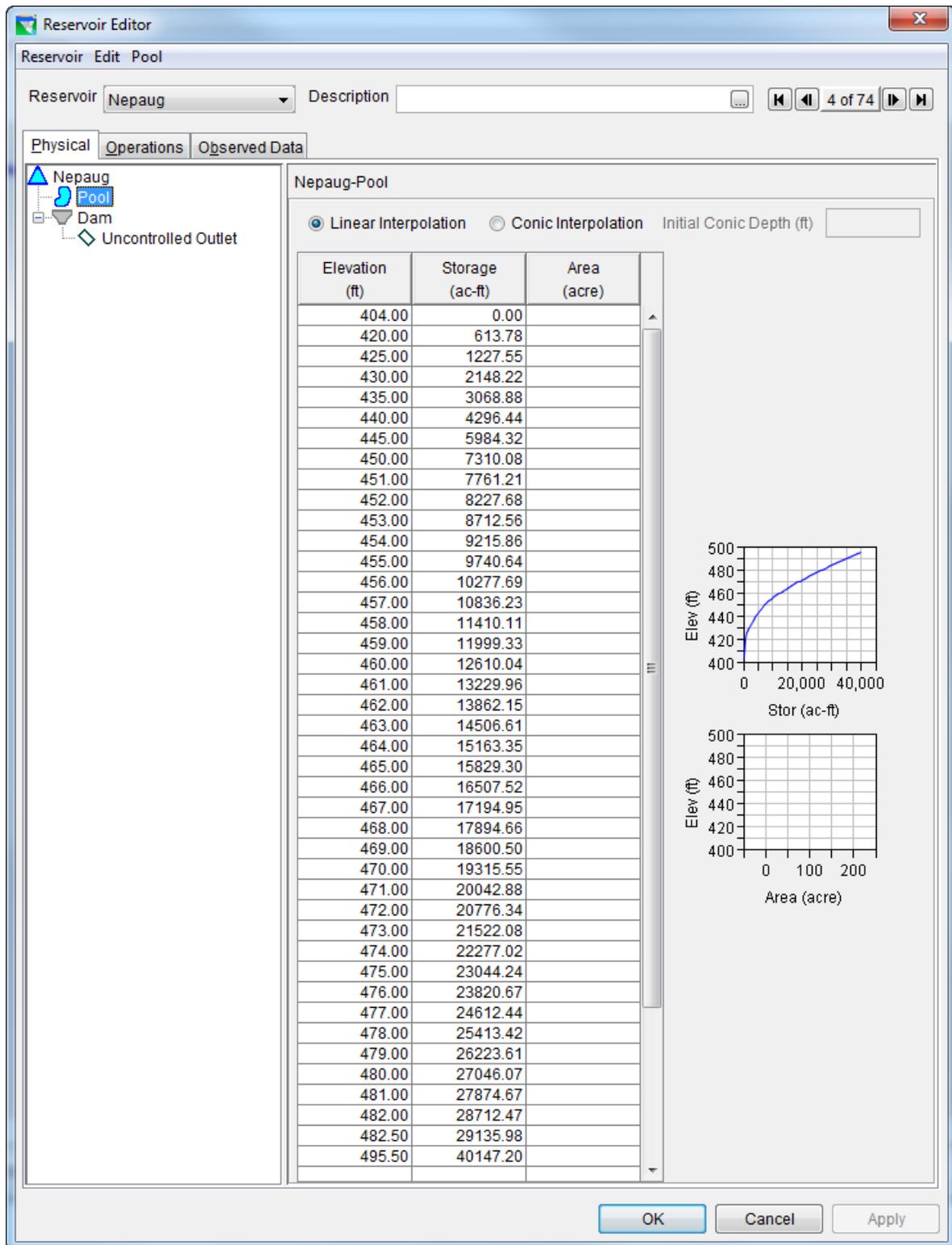


Figure 3: Reservoir Editor: Physical Tab -- Pool

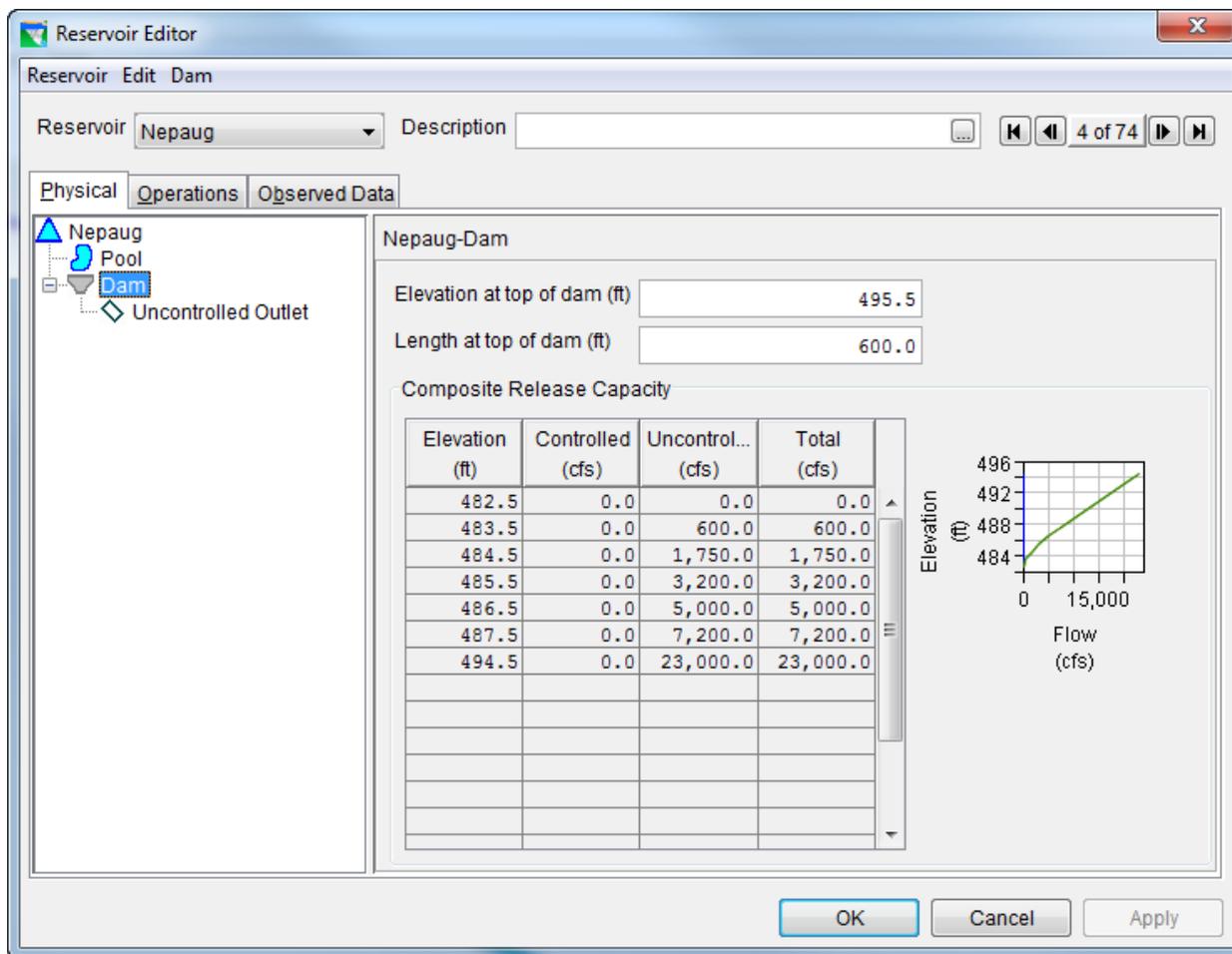


Figure 4: Reservoir Editor: Physical Tab -- Dam

### III. Operations

#### A. Operation Set

Zones are used to define the operational storage in the reservoir to determine the reservoir release through analysis of the rules contained within each zone. Figure 5 shows the definition of Nepaug’s “Existing Ops” operational zones, which consist of zones of Top of Dam (495.5ft), Conservation (482.5ft), and Inactive zone (417.5ft)<sup>2</sup>.

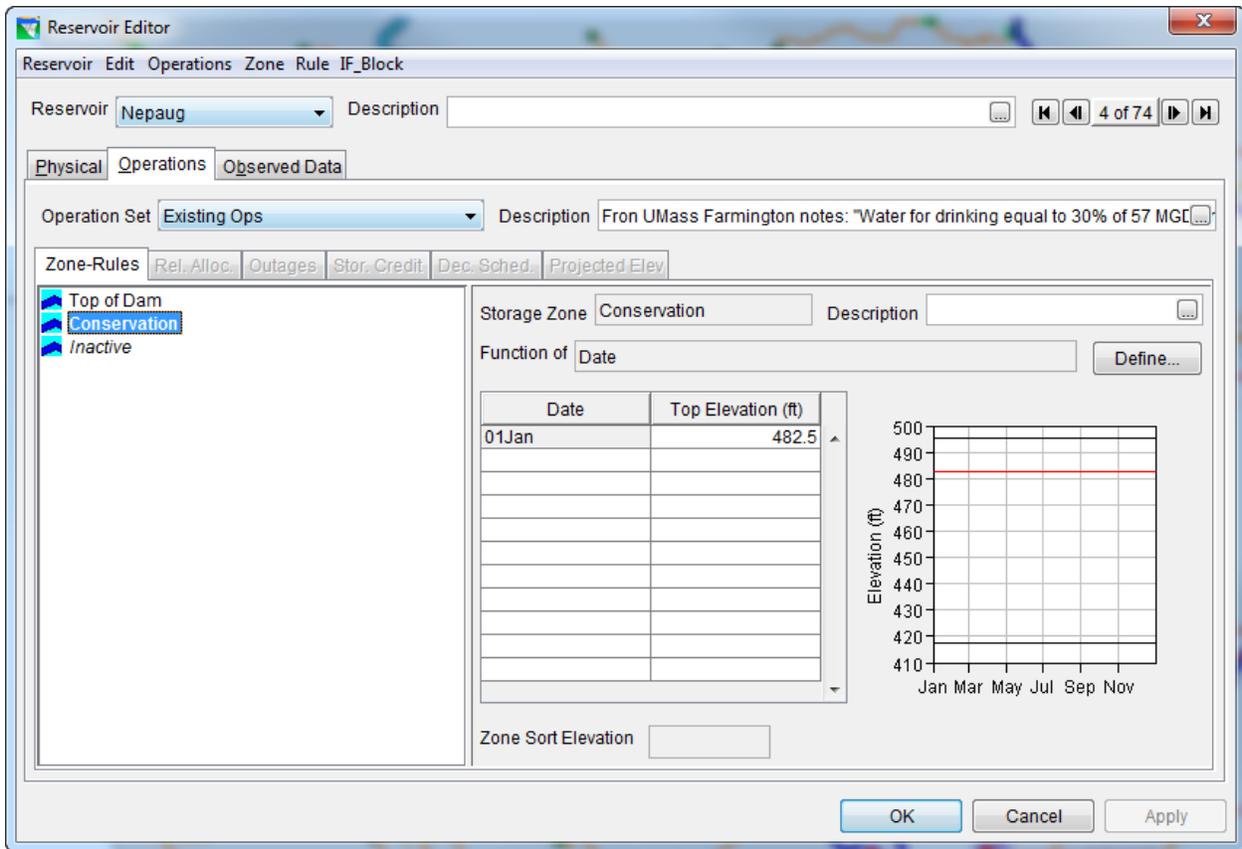


Figure 5: Reservoir Editor: Operations Tab – Existing Ops OpSet

## B. Rule Illustrations

The operation set for Nepaug has no rules of operation making it a flow through reservoir. The pool elevation will remain at the top of conservation unless the inflow exceeds the total release capacity.





**Figure 2: Photo of New Home Sewing Machine dam**

## **II. Physical Characteristics**

The physical characteristics of the reservoir are separated between the Pool and the Dam in the HEC-ResSim model. The elevation-storage-area defines the pool as shown in Figure 3<sup>72</sup>. The dam consists of five types of outlets: (1) controlled Dam Embankment, (2) controlled outlet, (3) power plant 1,(4) power plant 2, and (5) power plant 3 as shown in Figure 4<sup>73</sup>.

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<sup>72</sup> National Dam Inspection Program. Phase I Inspection Report. 1980.

<sup>73</sup> Mini-Watt Hydroelectric LLC. Stream Flow Compliance Plan. 2009.





### B. Rule Illustrations

Figure 6 shows a set of operational rules specified for each zone that reflects the operation set named Guide Curve.

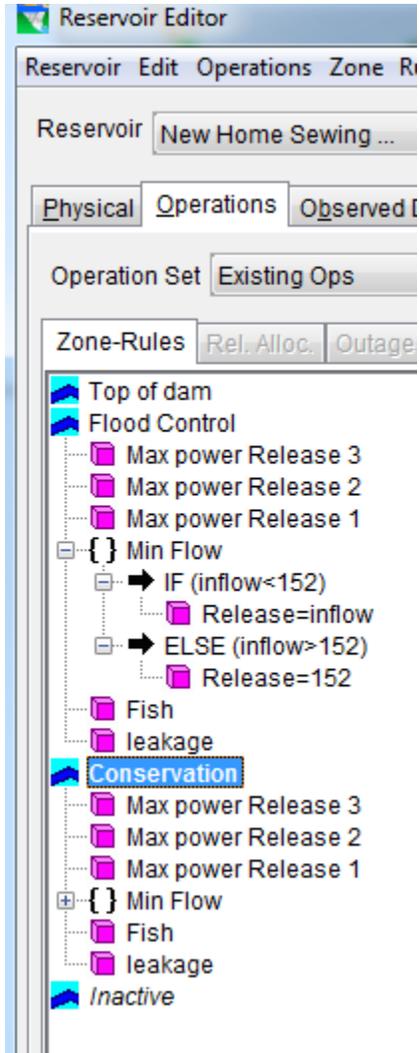


Figure 6: Reservoir Editor: Operations Tab – Existing Ops OpSet – Zones and Rules





Operation Set Existing Ops Description

Zone-Rules Rel. Alloc. Outages Stor. Credit Dec. Sched. Projected Elev

- Top of dam
- Flood Control
  - Max power Release 3
  - Max power Release 2
  - Max power Release 1
  - Min Flow
    - IF (inflow<152)
      - Release=inflow
    - ELSE (inflow>152)
      - Release=152
  - Fish
  - leakage
- Conservation
  - Max power Release 3
  - Max power Release 2
  - Max power Release 1
  - Min Flow
    - Fish
    - leakage
- Inactive

Operates Release From: New Home Sewing Machine-Power Plant 1

IF Conditional inflow<152 Description:

Value1		Value2
New Home Sewing Machi...	<	152

Add Cond. Del. Cond. Move Up Move Down Evaluate

Logical Operator: Operat... Value 1 Constant Value 2 Constant

Operation Set Existing Ops Description

Zone-Rules Rel. Alloc. Outages Stor. Credit Dec. Sched. Projected Elev

- Top of dam
- Flood Control
  - Max power Release 3
  - Max power Release 2
  - Max power Release 1
  - Min Flow
    - IF (inflow<152)
      - Release=inflow
    - ELSE (inflow>152)
      - Release=152
  - Fish
  - leakage
- Conservation
  - Max power Release 3
  - Max power Release 2
  - Max power Release 1
  - Min Flow
    - Fish
    - leakage
- Inactive

Operates Release From: New Home Sewing Machine-Dam

Rule Name: Release=inflow Description:

Function of: New Home Sewing Machine-Pool Net Inflow, Current Value Define...

Limit Type: Minimum Interp.: Line...

Flow (cfs)	Release (cfs)
0.0	0.0
1000.0	1000.0

Period Average Limit Hour of Day Multiplier Day of Week Multiplier Rising/Falling Condition Seasonal Variation Edit... Edit... Edit... Edit... Edit...



5. Fish

Figure 11 shows the content of “Fish” rule. It shows the minimum release from dam for Fish.

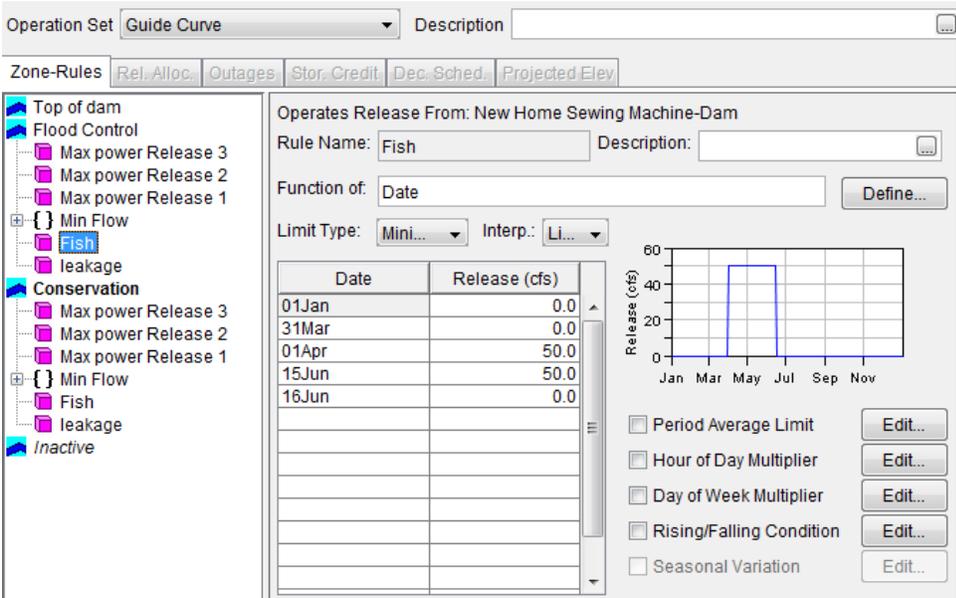


Figure 11: Reservoir Editor: Operations Tab – Guide Curve OpSet – Fish

6. leakage

Figure 12 shows the content of “leakage” rule. It shows the minimum release from dam for leakage.

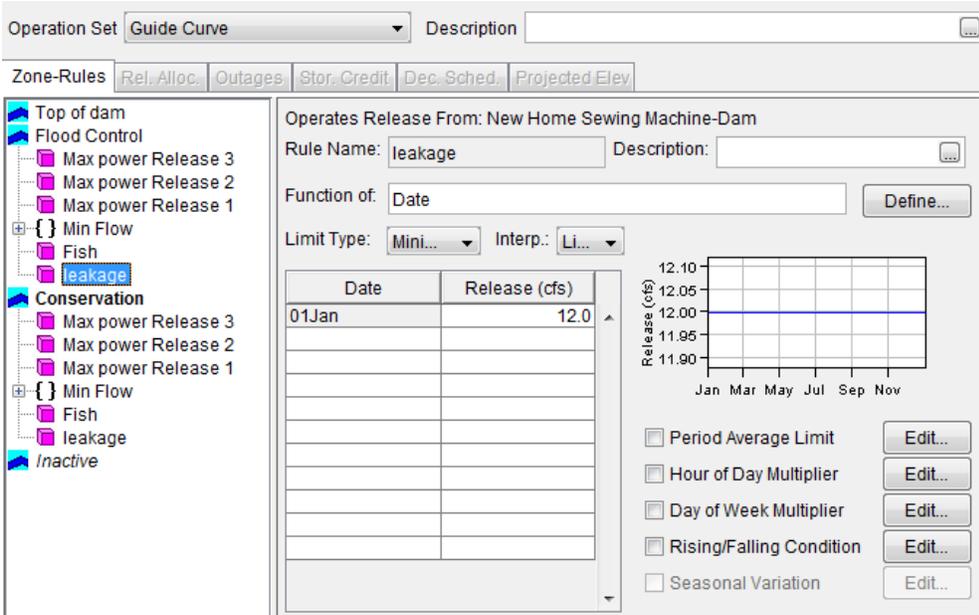


Figure 12: Reservoir Editor: Operations Tab – Guide Curve OpSet – leakage

# North Hartland

## I. Overview

North Hartland Dam is a dam in Hartland, Windsor County, Vermont. It was constructed in 1961 by the US Army Corps of Engineers and is still owned and operated by the Corps. It is primarily used for flood control purposes but is also used for recreation.

Figure 1 shows the location of North Hartland Dam as it is represented in the HEC-ResSim model. Figure 2 shows a photo of the dam.

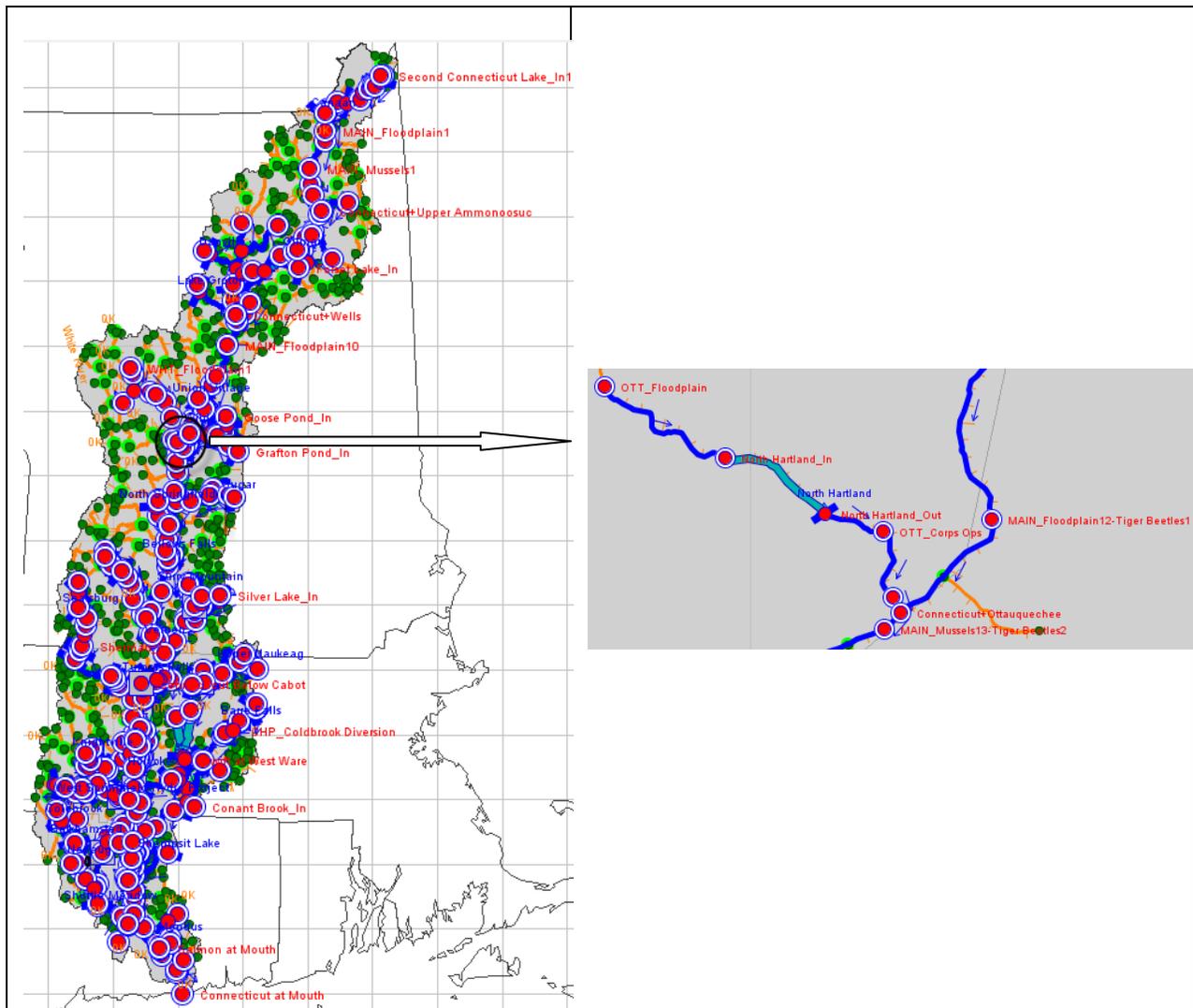


Figure 1: HEC-ResSim Map Display Showing Location of North Hartland dam



Figure 2: Photo of North Hartland Dam

## II. Physical Characteristics

The physical characteristics of the reservoir are separated between the Pool and the Dam in the HEC-ResSim model. The elevation-storage-area defines the pool as shown in Figure 3. The dam consists of two types of outlets: (1) controlled slide gates, and (2) uncontrolled outlet, as shown in Figure 4. All physical and operations data were provided by US Army Corps New England District, through both a previously created ResSim model and the Reservoir Regulation Team website<sup>74</sup>.

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<sup>74</sup> [http://rsgisias.crrel.usace.army.mil/nae/cwms\\_map.map\\_index](http://rsgisias.crrel.usace.army.mil/nae/cwms_map.map_index)

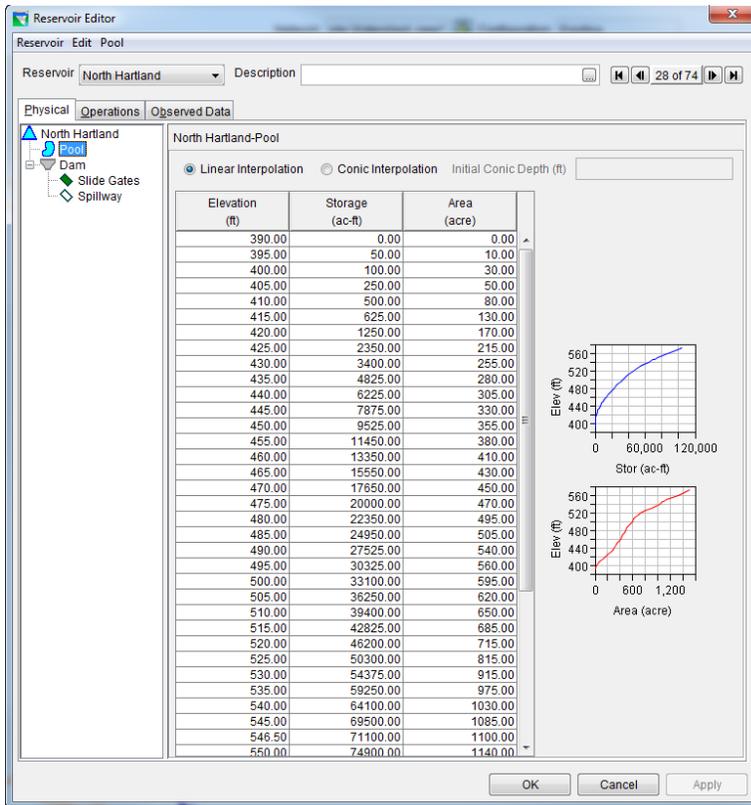


Figure 3: Reservoir Editor: Physical Tab -- Pool

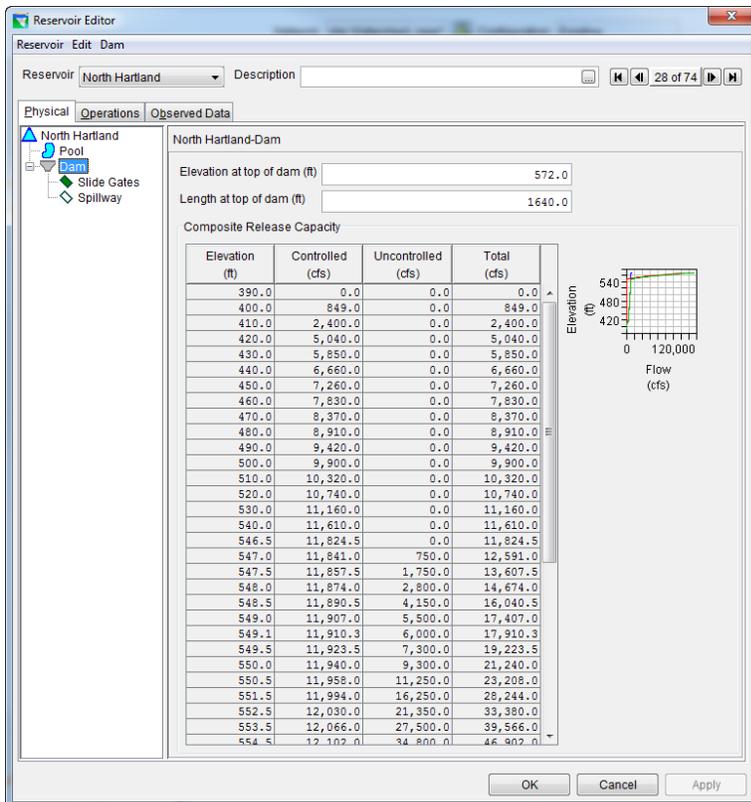


Figure 4: Reservoir Editor: Physical Tab -- Dam



## B. Rule Illustrations

Figure 6 shows a set of operational rules specified for each zone that reflects the operation set named Existing Ops. As described in the Simulation/Verification section of the report, adjustments were made to the operations to closer match gauge data.

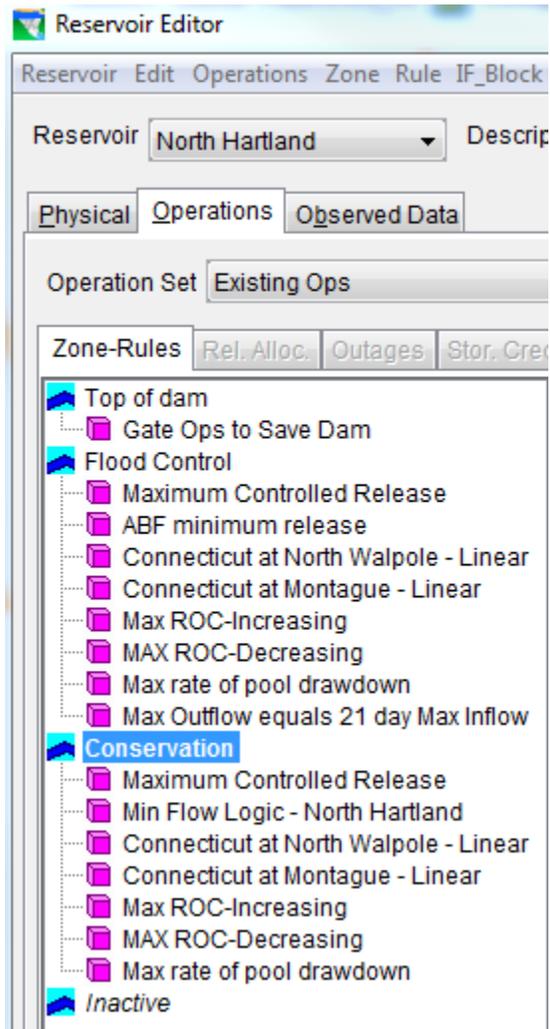


Figure 6: Reservoir Editor: Operations Tab – Existing Ops OpSet – Zones and Rules

## C. Rule Descriptions

### 1. Gate Ops to Save Dam

Figure 7 shows the content of “Gate Ops to Save Dam” rule. This rule represents the maximum allowable release from Slide gates as a function of pool elevation when the pool is in Top of dam zone.

The screenshot displays the 'Reservoir Editor' interface for the 'Existing Ops' set. The 'Zone-Rules' tab is active, showing a tree view on the left with 'Top of dam' expanded to 'Gate Ops to Save Dam'. The main configuration area shows the rule name and description, the function 'rtland-Pool Elevation, Period Average, 0.0 hr lag, 48.0 hr perio', and the limit type 'Maximu...'. A table lists the release rates for various elevations, and a graph plots Release (cfs) against Elev (ft). On the right, there are checkboxes for 'Period Average Limit', 'Hour of Day Multiplier', 'Day of Week Multiplier', 'Rising/Falling Condition', and 'Seasonal Variation', each with an 'Edit...' button.

Elev (ft)	Release (cfs)
546.5	6000.0
547.0	5250.0
547.5	4250.0
548.0	3200.0
548.5	1850.0
549.0	500.0
549.1	0.0
550.5	0.0
551.5	1500.0
552.5	1900.0
553.5	3200.0
554.5	4000.0
555.5	4500.0
556.5	6000.0
572.0	7000.0

Figure 7: Reservoir Editor: Operations Tab – Existing Ops OpSet –Gate Ops to Save Dam



#### 4. Connecticut at North Walpole-Linear

Figure 10 shows the content of “Connecticut at North Walpole-Linear” rule. This rule represents the maximum allowable release from the dam as a function of the previous day stage at North Walpole. The previous day stage was used to account for the delay that occurs between the stage exceeding the specified target and the change in operations at the flood control dams that occurs in reality.

The screenshot displays the 'Operations Tab' for an 'Existing Ops' set. The 'Zone-Rules' tree on the left shows the 'Connecticut at North Walpole - Linear' rule selected under the 'Flood Control' category. The main configuration area shows the rule name and function. A table defines the release limits based on stage, and a graph visualizes this relationship. Below the table, several checkboxes for advanced settings are visible, all of which are currently unchecked.

Stage (ft)	Release (cfs)
0.0	6000.0
24.0	6000.0
25.0	4800.0
26.0	3600.0
27.0	2400.0
28.0	1200.0
29.0	0.0
50.0	0.0

Figure 10: Reservoir Editor: Operations Tab – Existing Ops OpSet –Connecticut at North Walpole-Linear

### 5. Connecticut at Montague-Linear

Figure 11 shows the content of “Connecticut at Montague-Linear” rule. This rule represents the maximum allowable release from the dam as a function of the previous day stage at Montague. The previous day stage was used to account for the delay that occurs between the stage exceeding the specified target and the change in operations at the flood control dams that occurs in reality.

Operation Set: Existing Ops | Description: [ ]

Zone-Rules: Rel. Alloc. | Outages | Stor. Credit | Dec. Sched. | Projected Elev.

Operates Release From: North Hartland

Rule Name: cicut at Montague - Linear | Description: [ ]

Function of: Connecticut at Montague Stage, Previous Value | Define...

Limit Type: Maximu... | Interp.: Line...

Stage (ft)	Release (cfs)
0.0	6000.0
26.0	6000.0
27.0	4800.0
28.0	3600.0
29.0	2400.0
30.0	1200.0
31.0	0.0
50.0	0.0

Graph: Release (cfs) vs Stage (ft). The release is constant at 6000 cfs until stage 26 ft, then decreases linearly to 0 cfs at stage 31 ft, and remains at 0 cfs for higher stages.

Options:
 

- Period Average Limit | Edit...
- Hour of Day Multiplier | Edit...
- Day of Week Multiplier | Edit...
- Rising/Falling Condition | Edit...
- Seasonal Variation | Edit...

Figure 11: Reservoir Editor: Operations Tab – Existing Ops OpSet –Connecticut at Montague-Linear

### 6. Max ROC-Increasing

Figure 12 shows the content of “Max ROC-Increasing” rule. This rule shows the maximum allowable increasing release rate of change as a function of release from North Hartland dam.

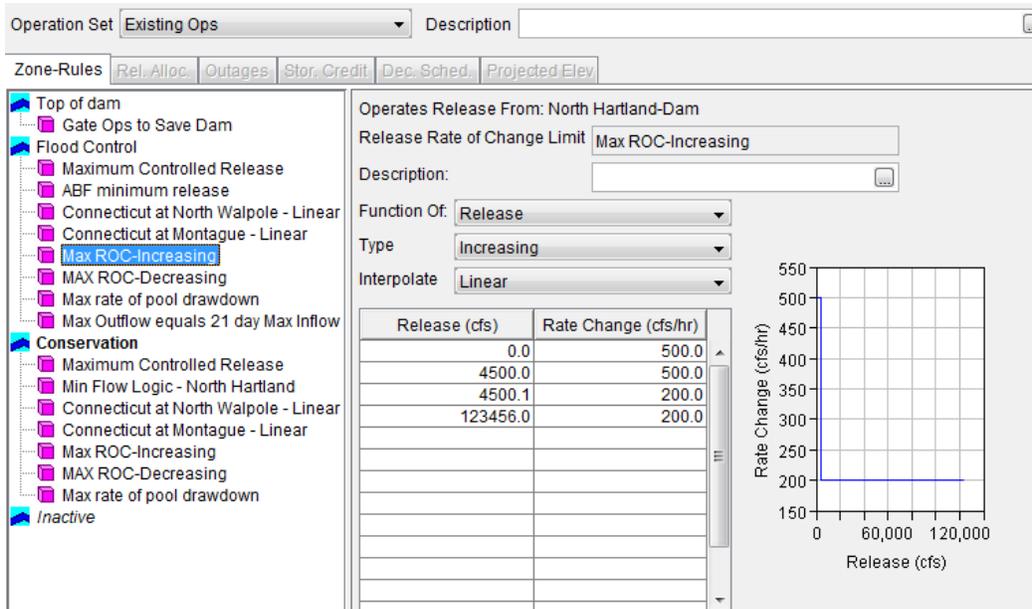


Figure 12: Reservoir Editor: Operations Tab – Existing Ops OpSet –Max ROC-Increasing

### 7. Max ROC-Decreasing

Figure 13 shows the content of “Max ROC-Decreasing” rule. This rule shows the maximum allowable decreasing release rate of change.

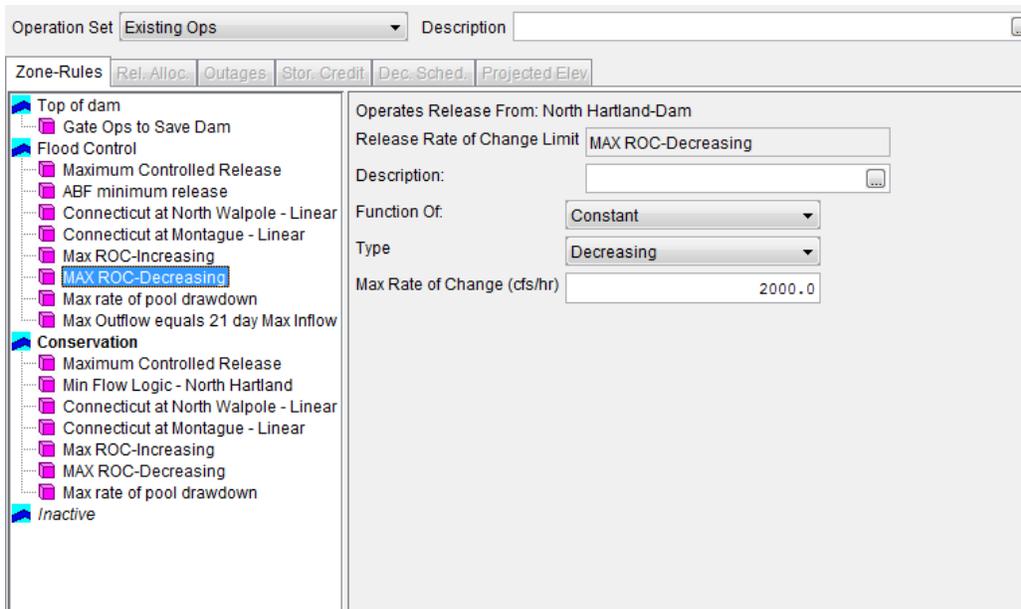


Figure 13: Reservoir Editor: Operations Tab – Existing Ops OpSet –Max ROC-Decreasing

### 8. Max rate of pool drawdown

Figure 14 shows the content of “Max rate of pool drawdown” rule. This rule shows the maximum allowable decreasing pool elevation rate of change.

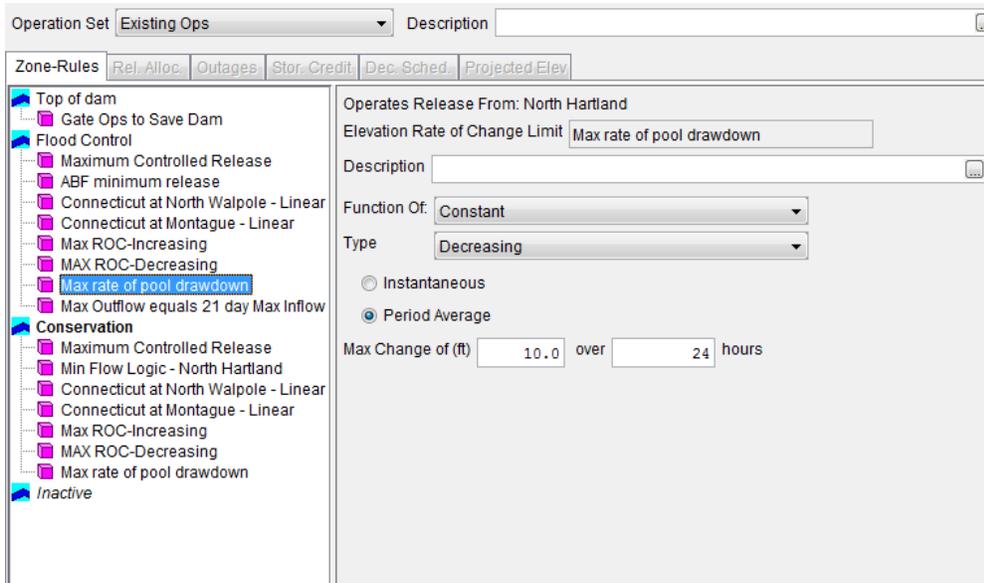


Figure 14: Reservoir Editor: Operations Tab – Existing Ops OpSet –Max rate of pool drawdown

### 9. Max Outflow equals 21 day Max Inflow

Figure 15 shows the content of “Max Outflow equals 21 day Max Inflow” rule. This rule represents the maximum release from dam as a function of the previous 3 weeks of inflow.

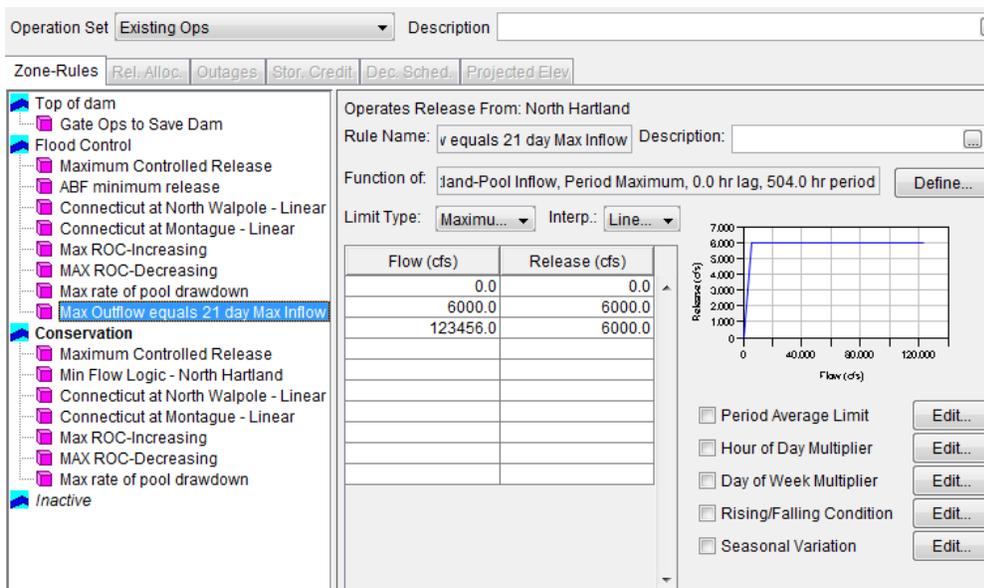


Figure 15: Reservoir Editor: Operations Tab – Existing Ops OpSet –Max Outflow equals 21 day Max Inflow

### 10. Min Flow Logic-North Hartland

Figure 16 shows the content of “Min Flow Logic-North Hartland” rule. This rule describes required seasonal minimum flows from controlled outlets as a function of inflow at North Hartland.

The screenshot displays the 'Operations Tab' in the Reservoir Editor. The 'Existing Ops' set is selected. The 'Min Flow Logic - North Hartland' rule is highlighted in the sidebar. The main configuration area shows the following details:

- Operates Release From:** North Hartland
- Rule Name:** low Logic - North Hartland
- Function of:** North Hartland-Pool Net Inflow, Current Value
- Limit Type:** Minimum
- Interp.:** Linear

Flow (cfs)	Release (cfs)			
	01Jan	01Apr	01Jun	01Oct
0.0	0.0	0.0	0.0	0.0
109.99	76.993	76.993	76.993	76.9...
110.0	77.0	77.0	110.0	77.0
219.99	153.993	153.993	110.0	153...
220.0	220.0	154.0	110.0	220.0
879.99	220.0	615.993	110.0	220.0
880.0	220.0	880.0	110.0	220.0
123456.0	220.0	880.0	110.0	220.0

The graph on the right shows 'Release (cfs)' on the y-axis (0 to 900) and 'Flow (cfs)' on the x-axis (0 to 120,000). A green line indicates the release values for different inflow levels, showing a step-like increase in release as inflow increases, with a maximum release of 220 cfs for inflows above 220 cfs.

Figure 16: Reservoir Editor: Operations Tab – Existing Ops OpSet –Min Flow Logic-North Hartland

## North Springfield

### I. Overview

North Springfield is a dam on the Black River in Central Vermont. It was constructed in 1960 by the US Army Corps of Engineers and is still owned and operated by the Corps. It is primarily used for flood control purposes but also for recreation.

Figure 1 shows the location of North Springfield Dam as it is represented in the HEC-ResSim model. Figure 2 shows a photo of the dam.

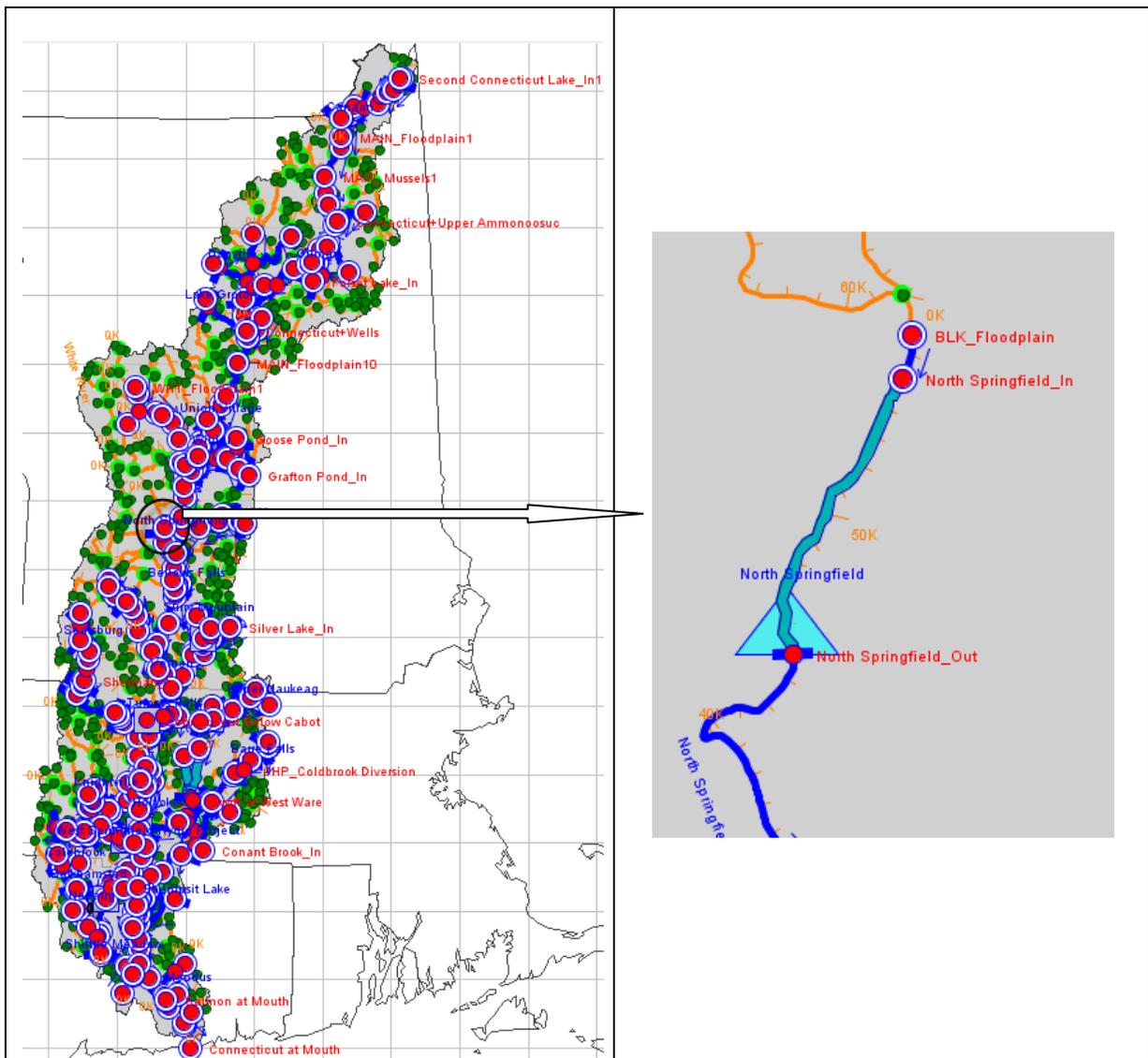


Figure 1: HEC-ResSim Map Display Showing Location of North Springfield dam



**Figure 2: Photo of North Springfield dam.**

## **II. Physical Characteristics**

The physical characteristics of the reservoir are separated between the Pool and the Dam in the HEC-ResSim model. The elevation-storage-area defines the pool as shown in Figure 3. The dam consists of two types of outlets: (1) controlled slide gates, and (2) uncontrolled spillway, as shown in Figure 4. All physical and operations data were provided by US Army Corps New England District, through both a previously created ResSim model and the Reservoir Regulation Team website<sup>75</sup>.

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<sup>75</sup> [http://rsgisias.crrel.usace.army.mil/nae/cwms\\_map.map\\_index](http://rsgisias.crrel.usace.army.mil/nae/cwms_map.map_index)

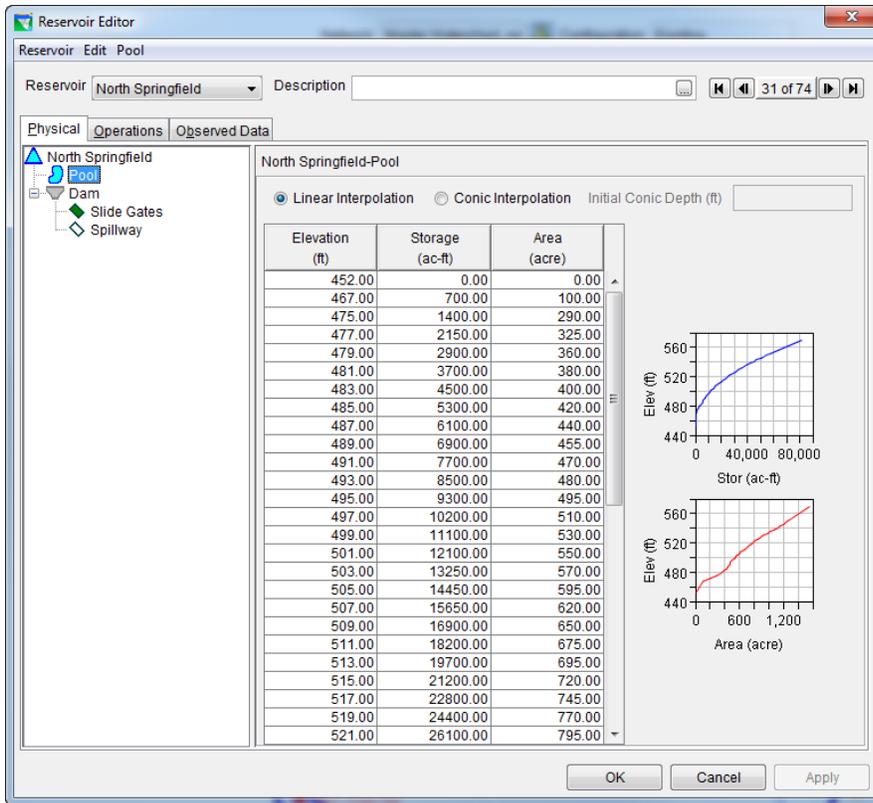


Figure 3: Reservoir Editor: Physical Tab -- Pool

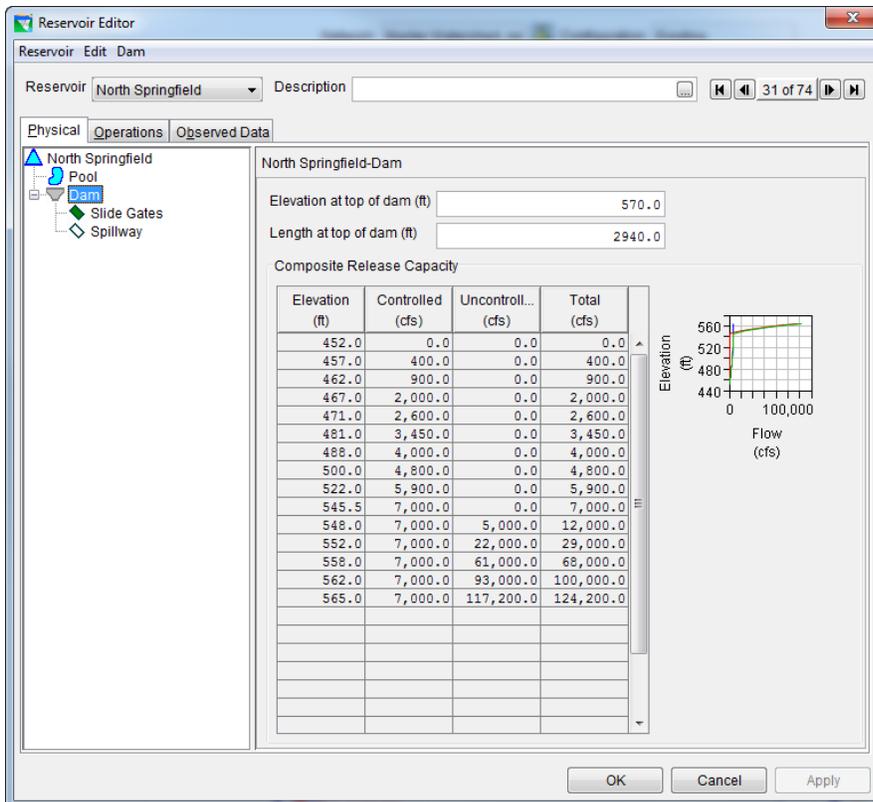


Figure 4: Reservoir Editor: Physical Tab -- Dam



## B. Rule Illustrations

Figure 6 shows a set of operational rules specified for each zone that reflects the operation set named Existing Ops. As described in the Simulation/Verification section of the report, adjustments were made to the operations to closer match gauge data.

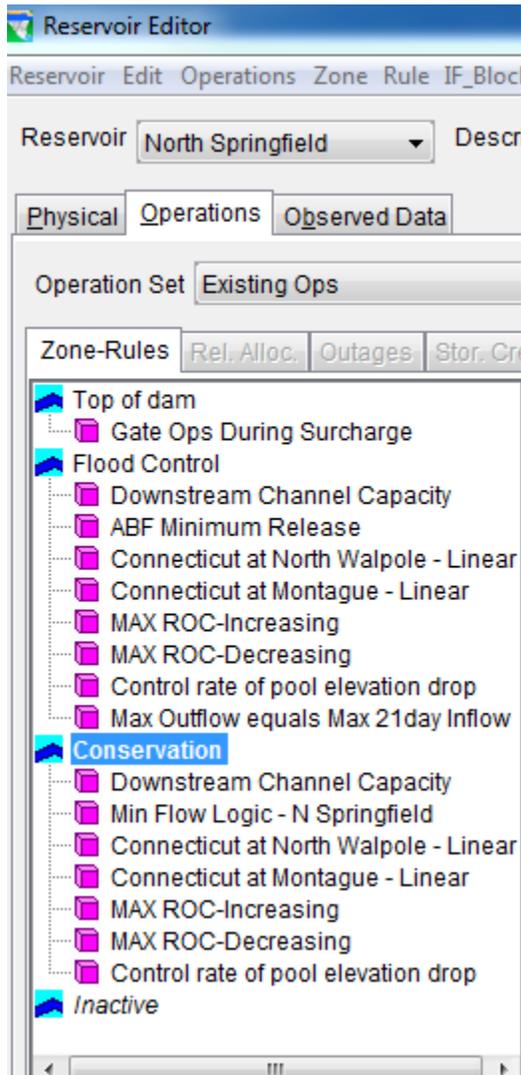


Figure 6: Reservoir Editor: Operations Tab – Existing Ops OpSet – Zones and Rules

## C. Rule Descriptions

### 1. Gate Ops During Surcharge

Figure 7 shows the content of “Gate Ops During Surcharge” rule. This rule represents the maximum allowable release from Slide gates as a function of pool elevation when the pool is in Top of dam zone.

The screenshot displays the 'Operations Tab' in the Reservoir Editor. The 'Existing Ops' set is selected. The 'Zone-Rules' section is expanded to 'Top of dam', where 'Gate Ops During Surcharge' is highlighted. The main configuration area shows the rule name and description, the function of the rule (Pool Elevation, Period Average, 0.0 hr lag, 48.0 hr period), and the limit type (Maximum). A table lists the release rates for various elevations, and a graph plots these rates. On the right, there are several checkboxes for advanced settings like 'Period Average Limit', 'Hour of Day Multiplier', etc., each with an 'Edit...' button.

Elev (ft)	Release (cfs)
545.5	3500.0
546.5	1900.0
547.25	0.0
547.5	0.0
548.5	0.0
549.5	0.0
550.5	1725.0
551.5	3725.0
552.5	5480.0
553.5	7250.0
554.5	7700.0
570.0	7700.0

Figure 7: Reservoir Editor: Operations Tab – Existing Ops OpSet – Gate Ops During Surcharge

## 2. Downstream Channel Capacity

Figure 8 shows the content of “Downstream Channel Capacity” rule. This rule represents the maximum allowable release from dam.

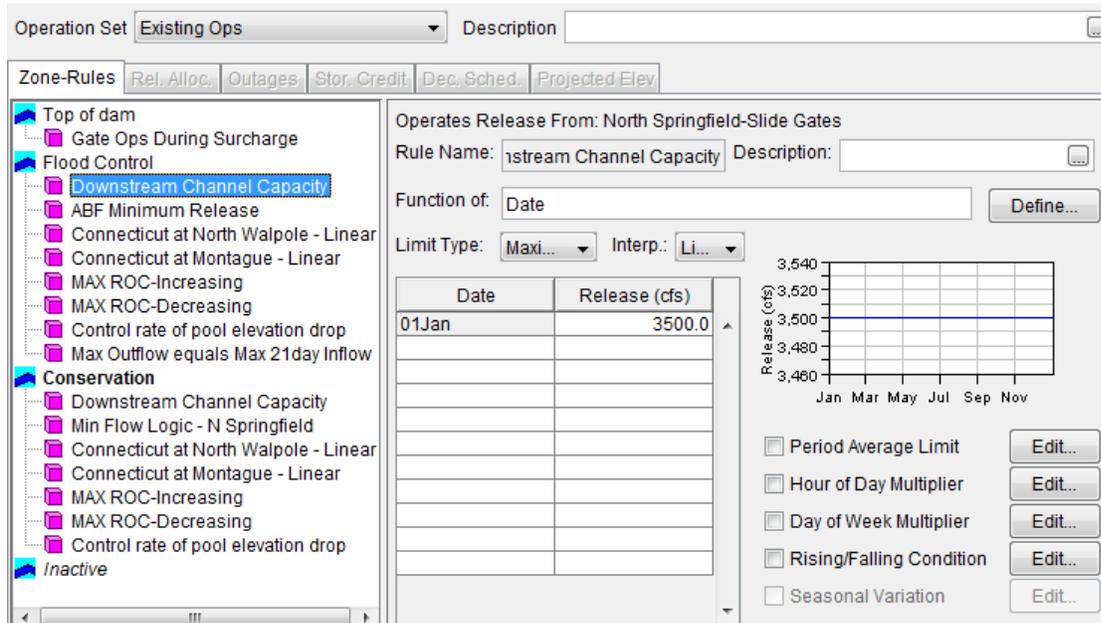


Figure 8: Reservoir Editor: Operations Tab – Existing Ops OpSet – Downstream Channel capacity

## 3. ABF Minimum Release

Figure 9 shows the content of “ABF Minimum Release” rule. This rule represents the minimum required release from slide gates during flood control operations.

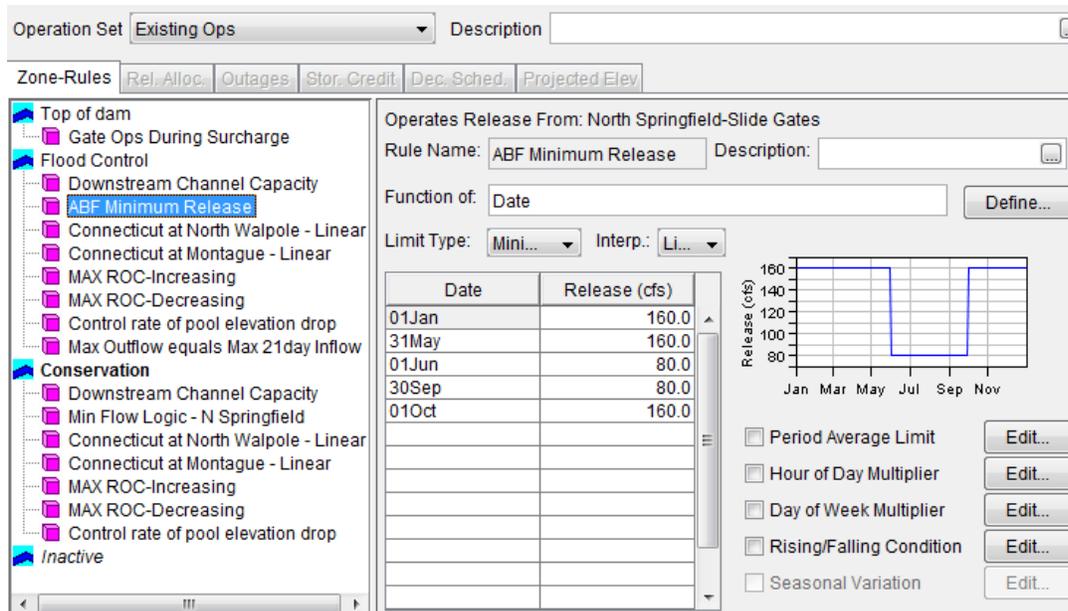


Figure 9: Reservoir Editor: Operations Tab – Existing Ops OpSet – ABF Minimum Release

#### 4. Connecticut at North Walpole-Linear

Figure 10 shows the content of “Connecticut at North Walpole-Linear” rule. This rule represents the maximum allowable release from the dam as a function of the previous day stage at North Walpole. The previous day stage was used to account for the delay that occurs between the stage exceeding the specified target and the change in operations at the flood control dams that occurs in reality.

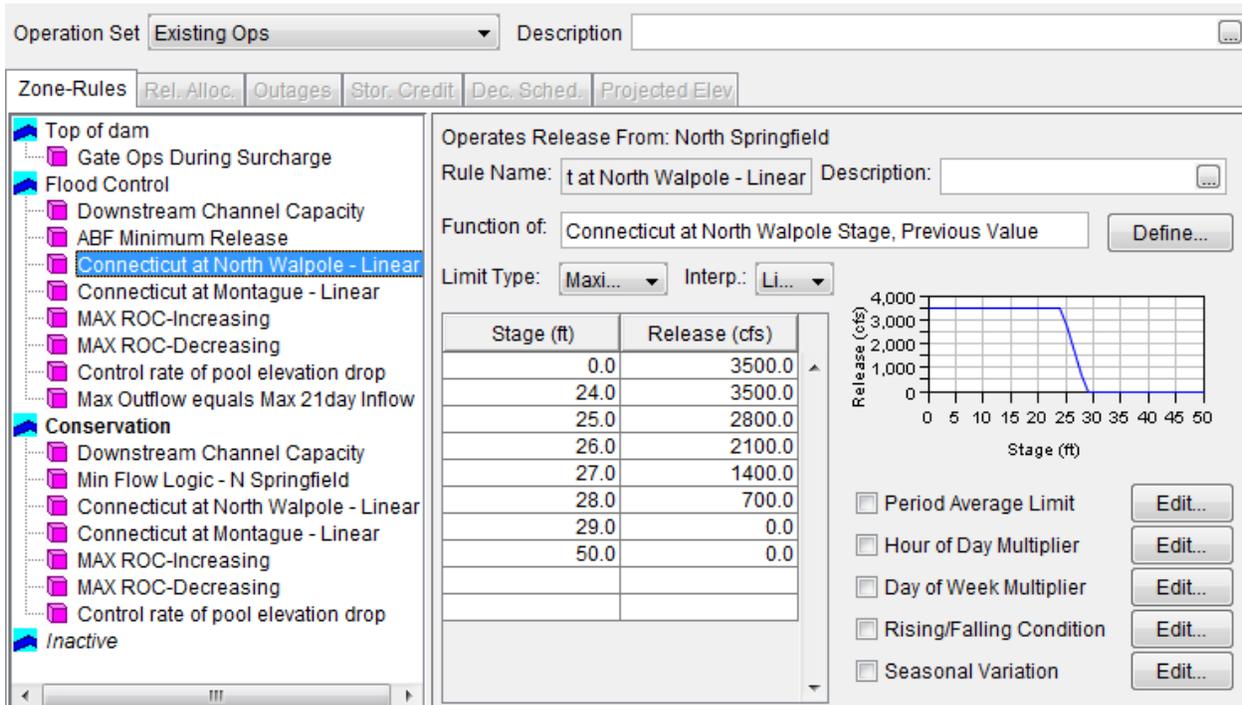


Figure 10: Reservoir Editor: Operations Tab – Existing Ops OpSet – Connecticut at North Walpole-Linear

### 5. Connecticut at Montague-Linear

Figure 11 shows the content of “Connecticut at Montague-Linear” rule. This rule represents the maximum allowable release from the dam as a function of the previous day stage at Montague. The previous day stage was used to account for the delay that occurs between the stage exceeding the specified target and the change in operations at the flood control dams that occurs in reality.

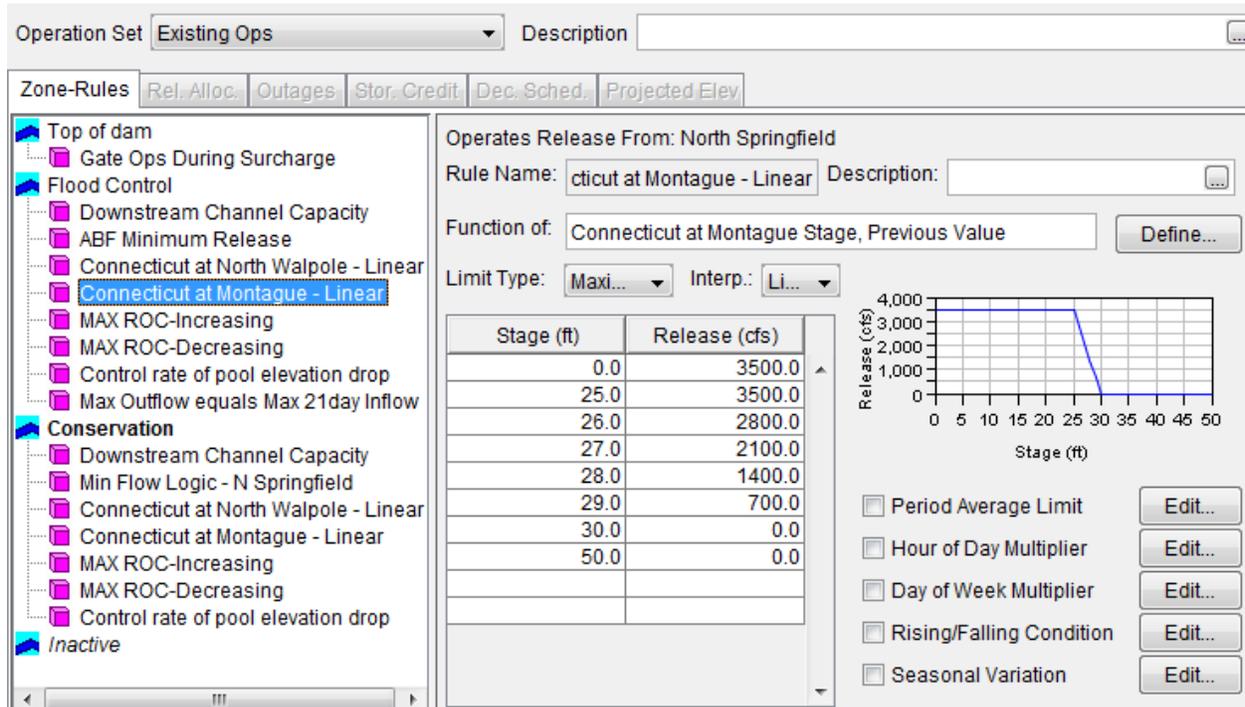


Figure 11: Reservoir Editor: Operations Tab – Existing Ops OpSet – Connecticut at Montague-Linear

### 6. MAX ROC-Increasing

Figure 12 shows the content of “MAX ROC-Increasing” rule. This rule shows the maximum allowable increasing release rate of change as a function of release from North Springfield dam.

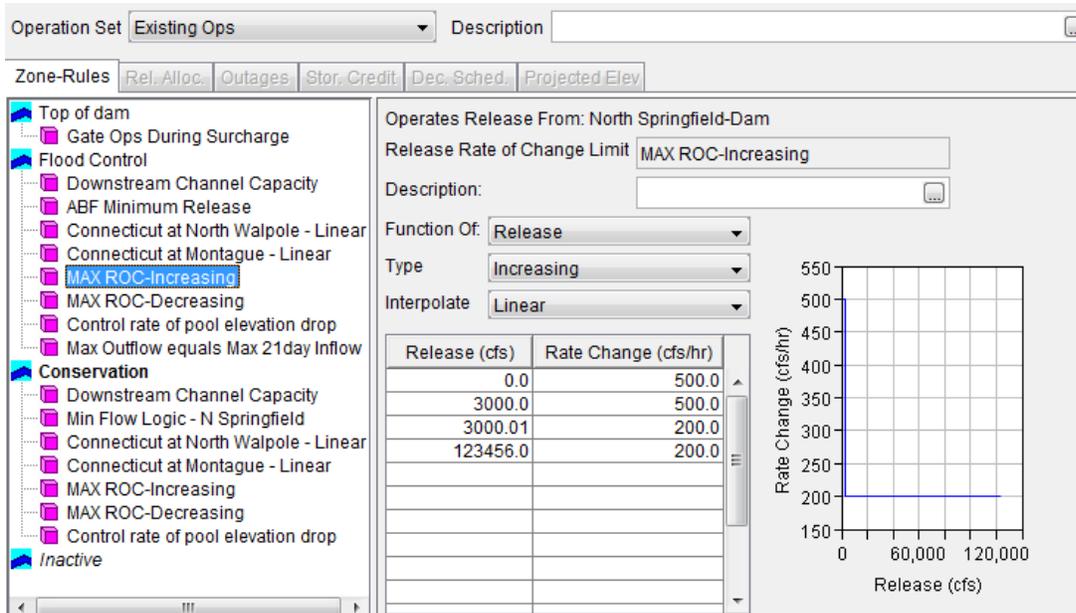


Figure 12: Reservoir Editor: Operations Tab – Existing Ops OpSet – MAX ROC-Increasing

### 7. MAX ROC-Decreasing

Figure 13 shows the content of “MAX ROC-Decreasing” rule. This rule shows the maximum allowable decreasing release rate of change.

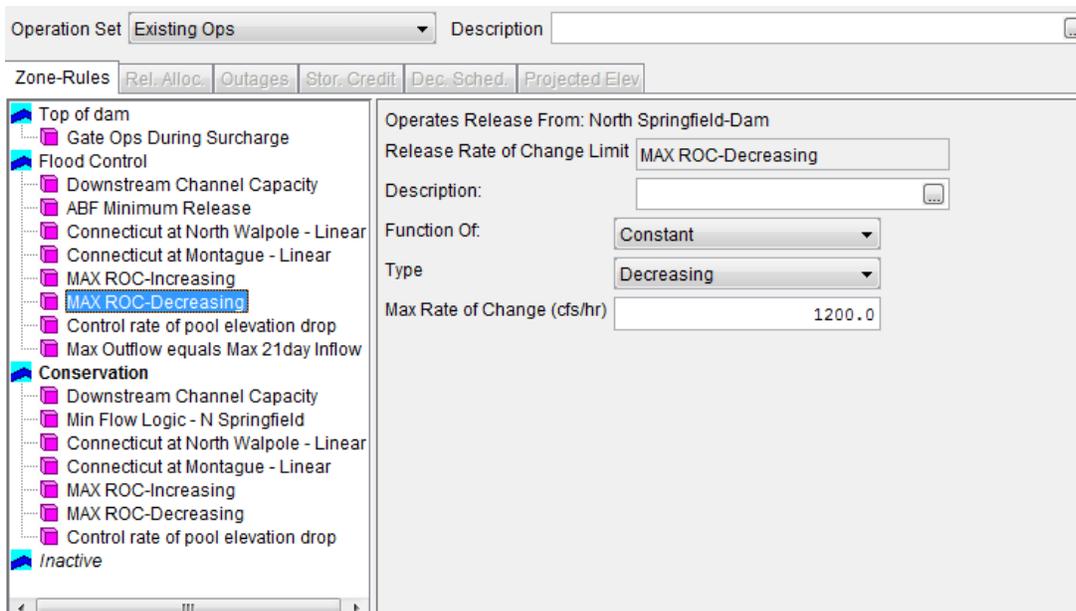


Figure 13: Reservoir Editor: Operations Tab – Existing Ops OpSet – MAX ROC-Decreasing

### 8. Control rate of pool elevation drop

Figure 14 shows the content of “Control rate of pool elevation drop” rule. This rule shows the maximum allowable decreasing pool elevation rate of change.

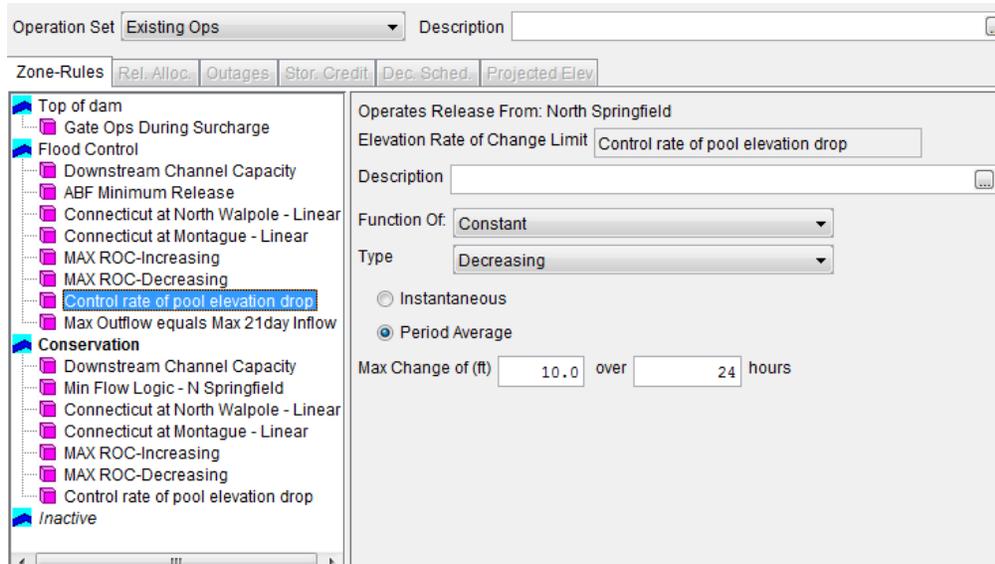


Figure 14: Reservoir Editor: Operations Tab – Existing Ops OpSet – Control rate of pool elevation drop

### 9. Max Outflow equals Max 21 day Inflow

Figure 15 shows the content of “Max outflow equals Max 21 day Inflow” rule. This rule represents the maximum release from dam as a function of the previous 3 weeks of inflow.

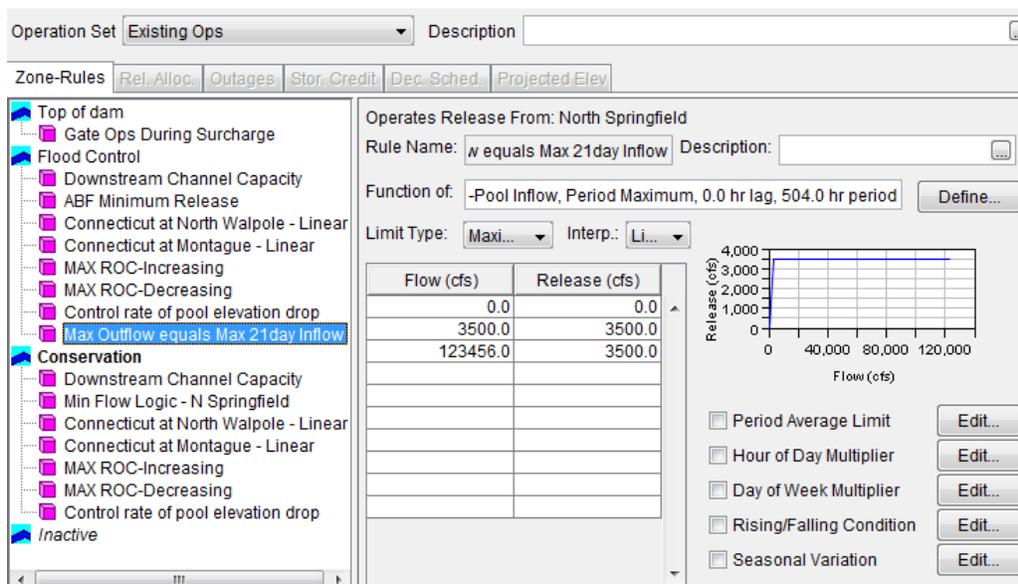


Figure 15: Reservoir Editor: Operations Tab – Existing Ops OpSet – Max Outflow equals Max 21 day Inflow

**10. Min Flow Logic-N Springfield**

Figure 16 shows the content of “Min Flow Logic-N Springfield” rule. This rule describes required seasonal minimum flows from controlled outlets as a function of inflow at North Springfield.

Operation Set: Existing Ops | Description: [ ]

Zone-Rules: Rel. Alloc. | Outages | Stor. Credit | Dec. Sched. | Projected Elev.

Operates Release From: North Springfield

Rule Name: Flow Logic - N Springfield | Description: [ ]

Function of: North Springfield-Pool Net Inflow, Current Value | Define...

Limit Type: Minimum | Interp.: Linear

Flow (cfs)	Release (cfs)			
	01Jan	01Apr	01Jun	01Oct
0.0	0.0	0.0	0.0	0.0
79.99	55.993	55.993	55.993	55.993
80.0	56.0	56.0	80.0	56.0
159.99	111.993	111.993	80.0	111.993
160.0	160.0	112.0	80.0	160.0
629.99	160.0	440.993	80.0	160.0
630.0	160.0	630.0	80.0	160.0
123456.0	160.0	630.0	80.0	160.0

Graph: Release (cfs) vs Flow (cfs). Shows a step function where release is constant at 160 cfs for inflows above 160 cfs, and follows a linear path for lower inflows.

Period Average Limit | Edit...  
 Hour of Day Multiplier | Edit...  
 Day of Week Multiplier | Edit...  
 Rising/Falling Condition | Edit...  
 Seasonal Variation | Edit...

Figure 16: Reservoir Editor: Operations Tab – Existing Ops OpSet – Min Flow Logic-N Springfield

# Northfield

## I. Overview

Northfield (full name Northfield Mountain) is a pump storage project located on the mainstem Connecticut River above Turners Falls. It is owned and operated by FirstLight Power Resource and is operated for hydropower generation in connection with the Turners Falls project, another FirstLight Power resources project.

Figure 1 shows the location of Northfield Mountain dam as it is represented in the HEC-ResSim model. Figure 2 shows a photo of the Northfield Mountain project.

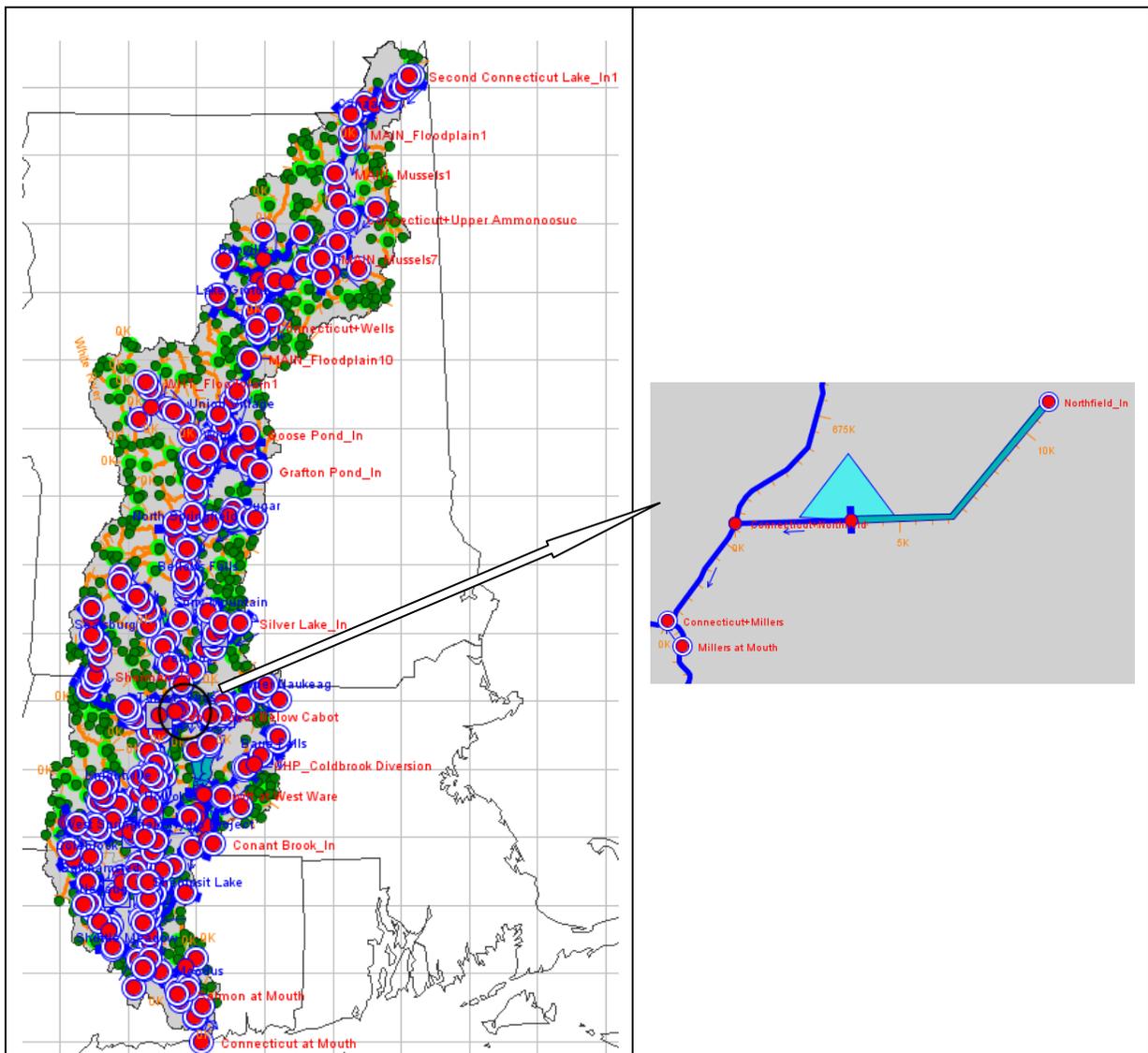


Figure 1: HEC-ResSim Map Display Showing Location of Northfield dam



**Figure 2: Photo of Northfield Mountain project**

## **II. Physical Characteristics**

The physical characteristics of the reservoir are separated between the Pool and the Dam in the HEC-ResSim model. The elevation-storage-area defines the pool as shown in Figure 3<sup>76</sup>. The dam consists of two types of outlets: (1) pump, and (2) Northfield Station, as shown in Figure 4.

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<sup>76</sup> All physical and operational data from ResSim model developed by Gomez and Sullivan Engineers, P.C.





## B. Rule Illustrations

Figure 6 shows a set of operational rules specified for each zone that reflects the operation set named Existing Ops<sup>1</sup>.

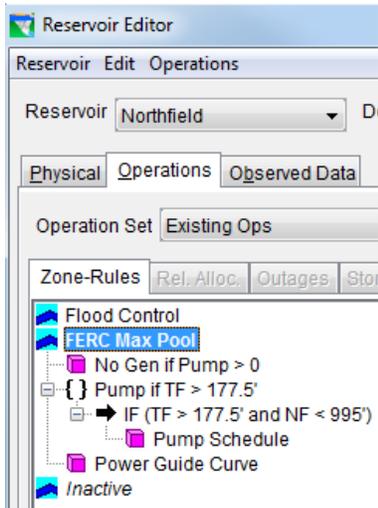


Figure 6: Reservoir Editor: Operations Tab – Existing Ops OpSet – Zones and Rules

## C. Rule Descriptions

### 1. No Gen if Pump>0

Figure 7 shows the content of “No Gen if Pump>0” rule. This rule represents that when water is pumped then no water is released from Northfield.

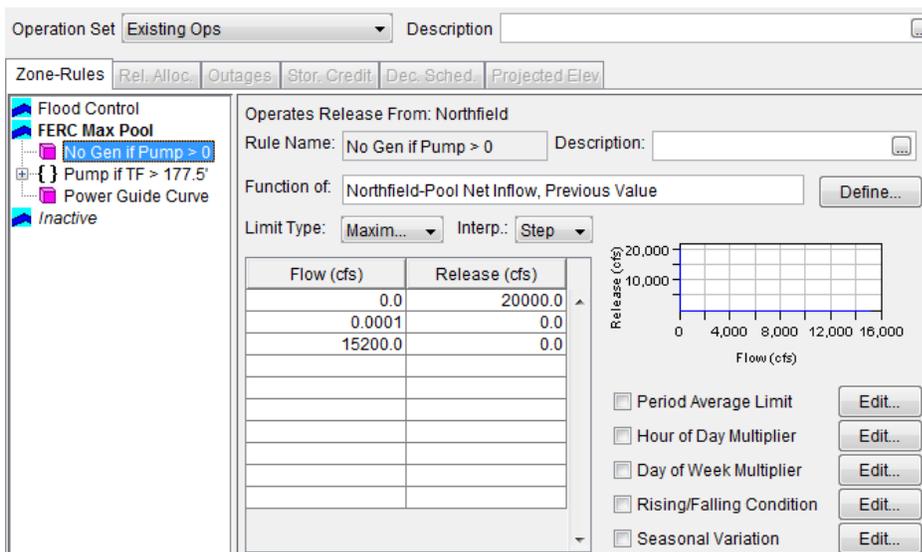


Figure 7: Reservoir Editor: Operations Tab – Existing Ops OpSet – No Gen if Pump>0

## 2. Pump if TF>177.5'

Figure 8 shows the content of “Pump if TF>177.5” rule. This rule shows that if Turner falls pool elevation is less than 175' and Northfield pool elevation is less than 995'then water is pumped.

The screenshot displays a software interface for configuring an operation set. The top section shows the 'Operation Set' dropdown set to 'Existing Ops' and a 'Description' field. Below this, there are tabs for 'Zone-Rules', 'Rel. Alloc.', 'Outages', 'Stor. Credit', 'Dec. Sched.', and 'Projected Elev.'. The left sidebar contains a tree view of rules, with 'Pump if TF > 177.5' selected. The main area shows the configuration for this rule, including its name, description, and a table of conditions.

**Operation Set:** Existing Ops  
**Description:** [Empty field]

**Zone-Rules:** Rel. Alloc. | Outages | Stor. Credit | Dec. Sched. | Projected Elev.

**Operates Release From:** Northfield

**Name:** Pump if TF > 177.5'    **Description:** Pump only if Turners Fall...

Type	Name	Description
IF	TF > 177.5' and NF < 995'	

**IF Conditional:** TF > 177.5' and NF < 995'    **Description:** [Empty field]

	Value1		Value2
	Turners Falls-Pool:Elevation	>	177.5
AND	Northfield-Pool:Elevation	<	995

**Buttons:** Add Cond., Del. Cond., Move Up, Move Down, Evaluate

**Logical Operator:** Value 1 Constant, Value 2 Constant

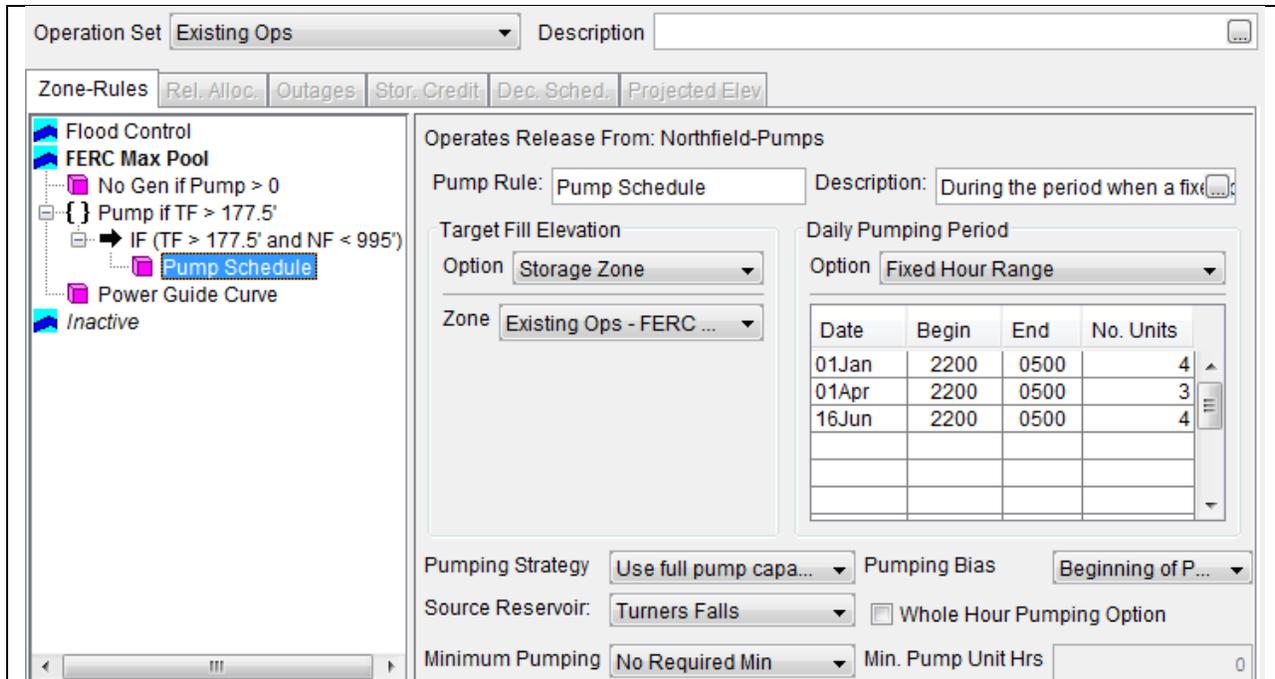


Figure 8: Reservoir Editor: Operations Tab – Existing Ops OpSet –Pump if TF>177.5’

### 3. Power Guide Curve

Figure 9 shows the content of “Power Guide Curve” rule. This rule shows the 9.6 hours of power generation in a day.

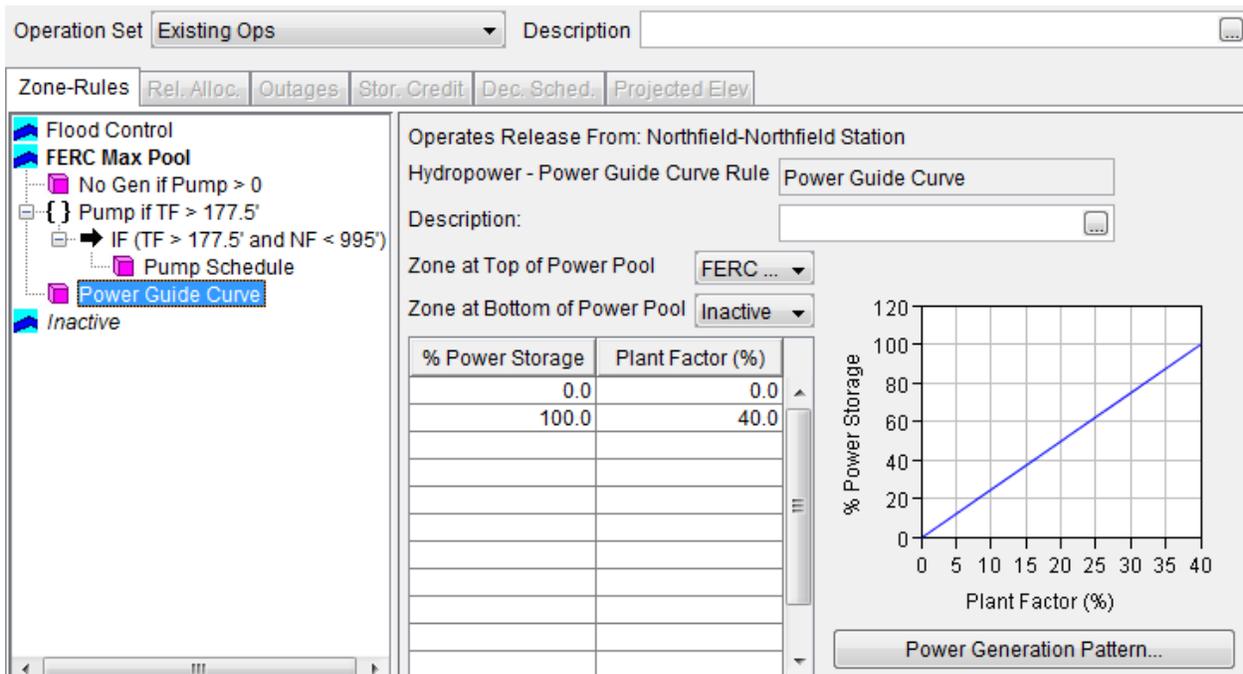


Figure 9: Reservoir Editor: Operations Tab – Existing Ops OpSet – Power Guide Curve

# Otis

## I. Overview

Otis dam is located in the towns of Otis and Tolland, MA on the west Branch of the Farmington River. It is owned and operated by the Massachusetts Department of Conservation and Recreation (DCR) and is used primarily for recreation.

Figure 1 shows the location of Otis dam as it is represented in the HEC-ResSim model. Figure 2 shows a photo of Otis dam.

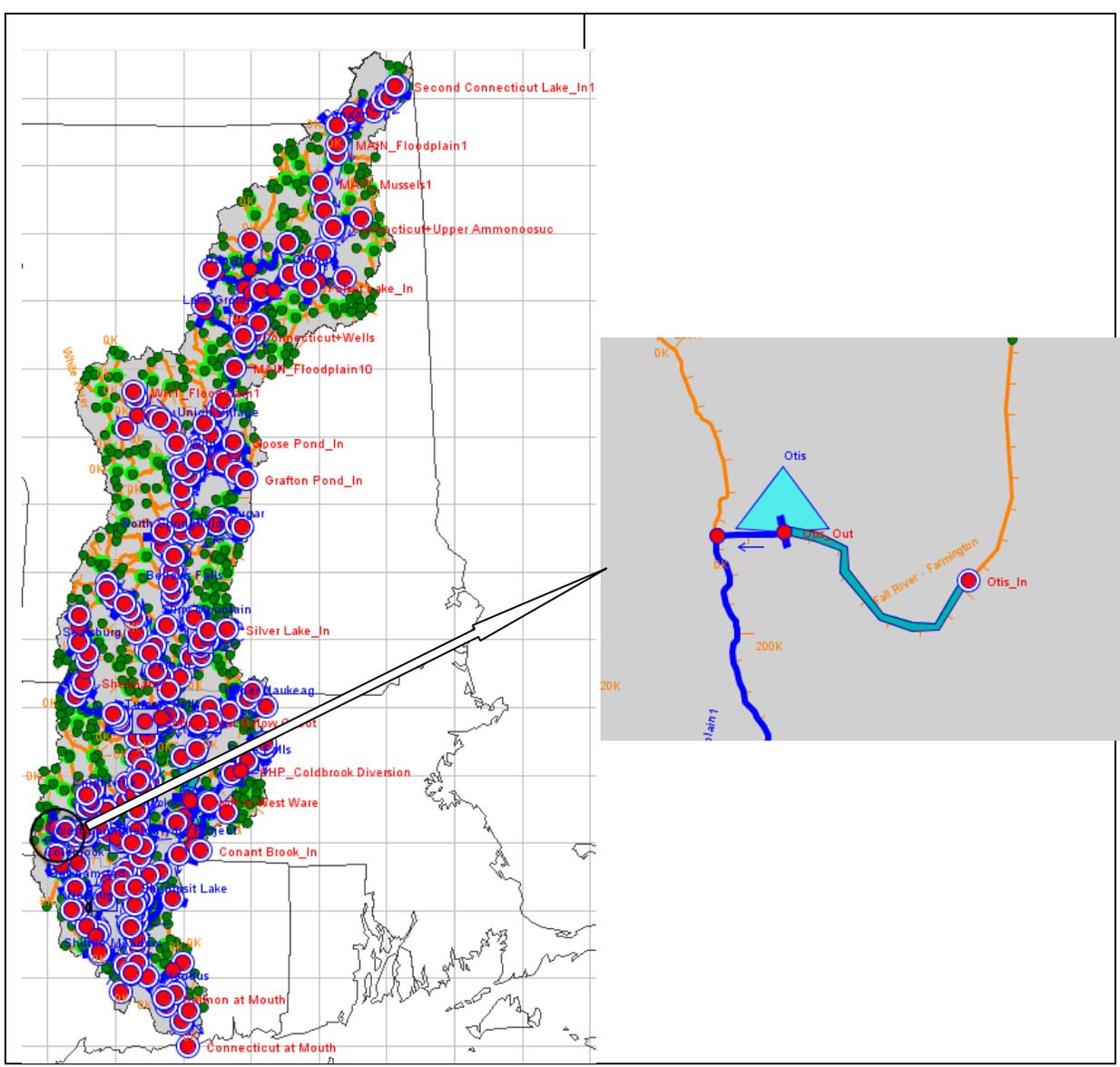


Figure 1: HEC-ResSim Map Display Showing Location of Otis dam



**Figure 2: Photo of Otis dam**

## **II. Physical Characteristics**

The physical characteristics of the reservoir are separated between the Pool and the Dam in the HEC-ResSim model. The elevation-storage-area defines the pool as shown in Figure 3<sup>77</sup>. The dam consists of two types of outlets: (1) controlled outlet, (2) uncontrolled spillway as shown in Figure 4.

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<sup>77</sup> Data from UMASS





### III. Operations

#### A. Operation Set

Zones are used to define the operational storage in the reservoir to determine the reservoir release through analysis of the rules contained within each zone. Figure 5 shows the definition of Otis’s “Existing Ops” operational zones, which consist of zones of Top of dam (1425.28 ft), conservation (1412.4-1420.6 ft), Min Pool, and Inactive zone (1400 ft)<sup>1</sup>.

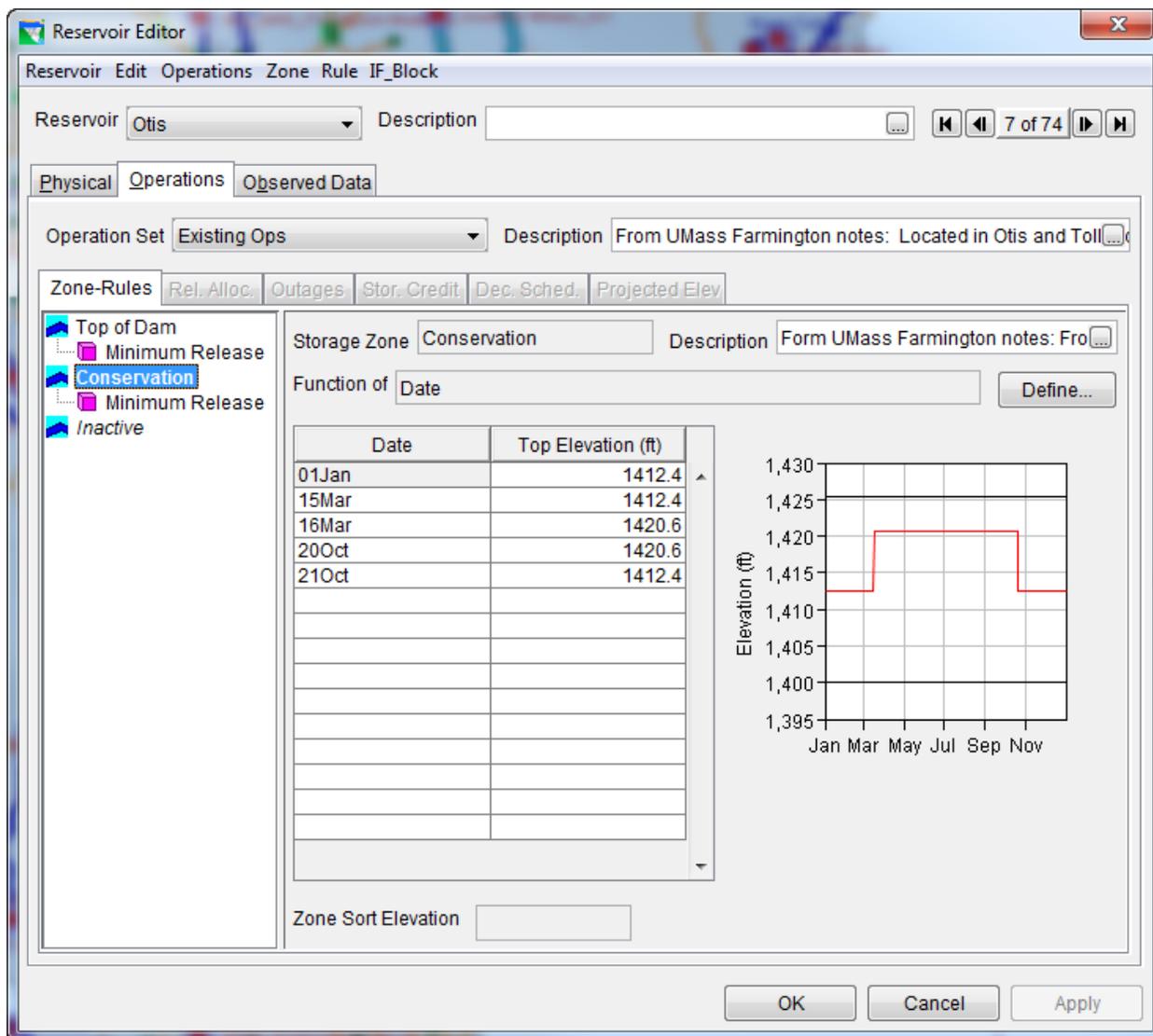


Figure 5: Reservoir Editor: Operations Tab –Existing Ops OpSet – Guide Curve

## B. Rule Illustrations

Figure 6 shows a set of operational rules specified for each zone that reflects the operation set named Existing Ops (Adamec, University of Massachusetts, Amherst).

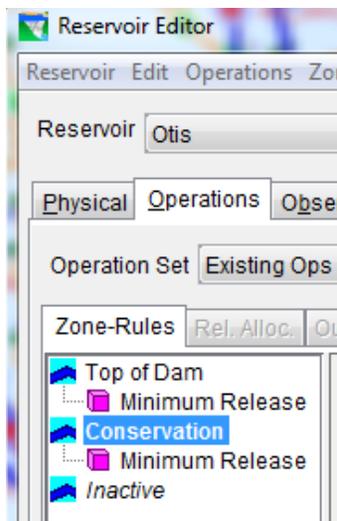


Figure 6: Reservoir Editor: Operations Tab – Existing Ops OpSet – Zones and Rules

## C. Rule Descriptions

### 1. Minimum Release

Figure 7 shows the content of “Minimum Release” rule. This rule represents a seasonal rule for minimum release from Otis reservoir.

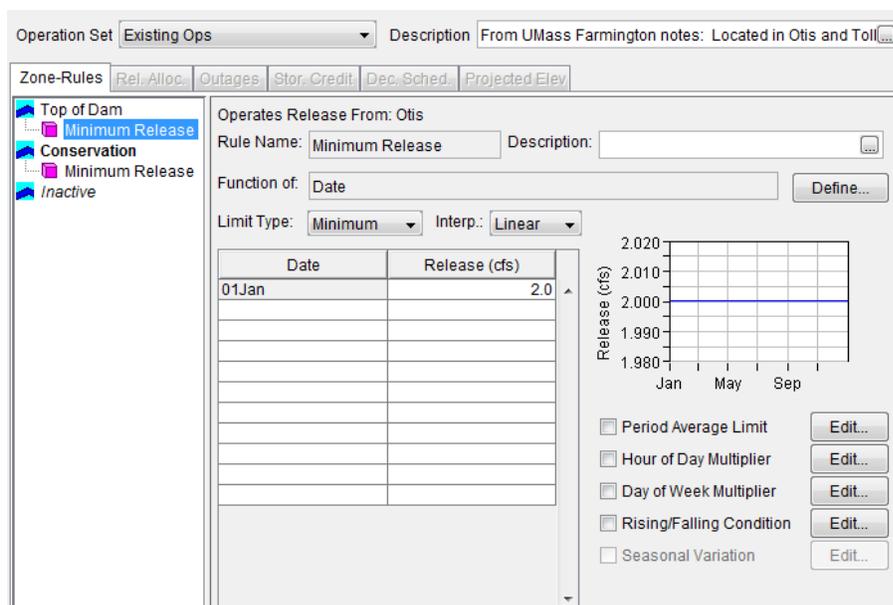


Figure 7: Reservoir Editor: Operations Tab – Existing Ops OpSet – Minimum Release

# Otter Brook

## I. Overview

Otter Brook dam is a dam on Otter Brook that flows into the Ashuelot River in New Hampshire. It was constructed in 1958 by the US Army Corps of Engineers and is still owned and operated by the Corps. It is primarily used for flood control but also for recreation.

Figure 1 shows the location of Otter Brook Dam as it is represented in the HEC-ResSim model, and Figure 2 shows a photo from Otter Brook dam.

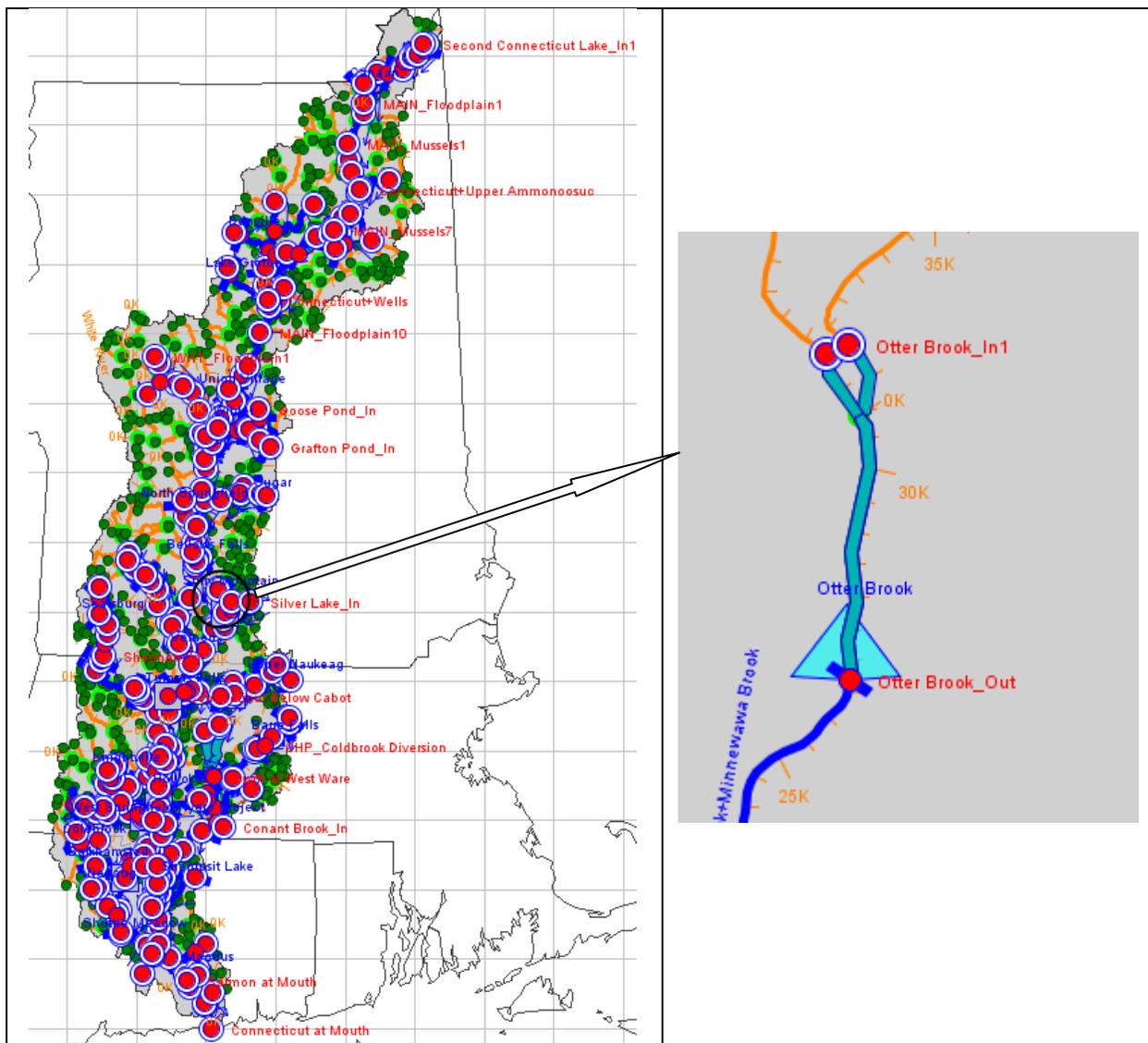


Figure 1: HEC-ResSim Map Display Showing Location of Otter Brook dam



Figure 2: Photo of Otter Brook Dam

## II. Physical Characteristics

The physical characteristics of the reservoir are separated between the Pool and the Dam in the HEC-ResSim model. The elevation-storage-area defines the pool as shown in Figure 3. The dam consists of two types of outlets: (1) controlled slide gates, and (2) uncontrolled spillway, as shown in Figure 4. All physical and operations data were provided by US Army Corps New England District, through both a previously created ResSim model and the Reservoir Regulation Team website<sup>78</sup>.

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<sup>78</sup> [http://rsgisias.crrel.usace.army.mil/nae/cwms\\_map.map\\_index](http://rsgisias.crrel.usace.army.mil/nae/cwms_map.map_index)

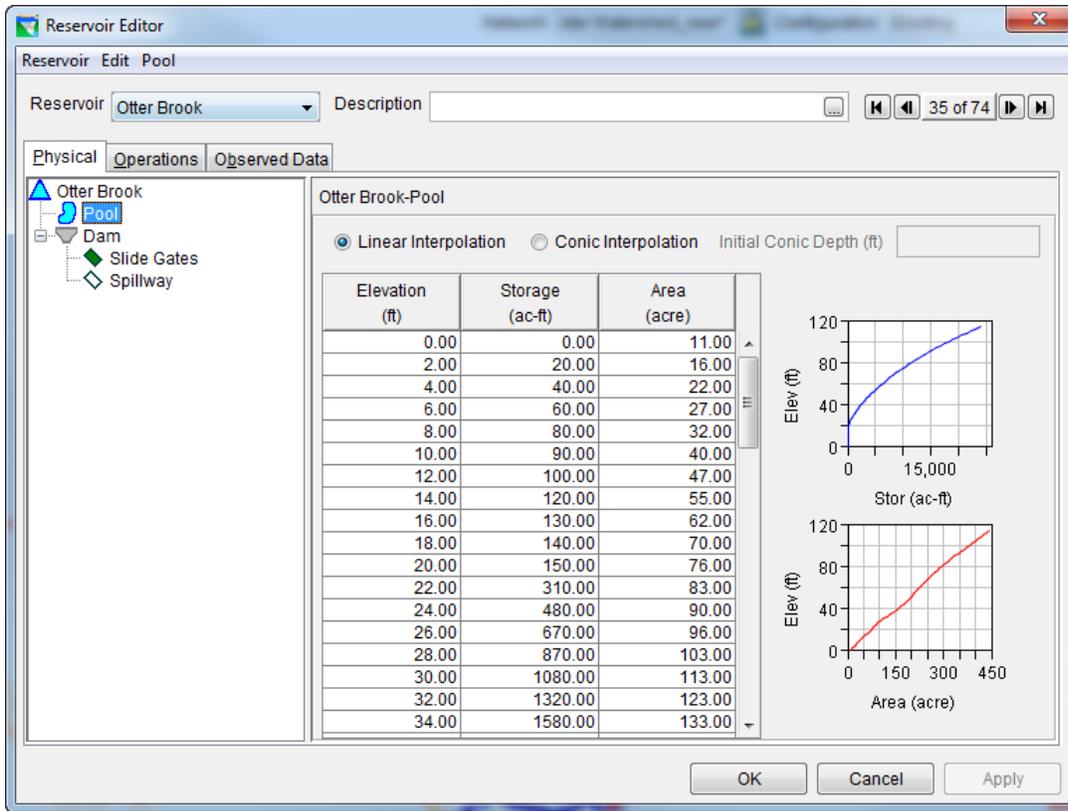


Figure 3: Reservoir Editor: Physical Tab -- Pool

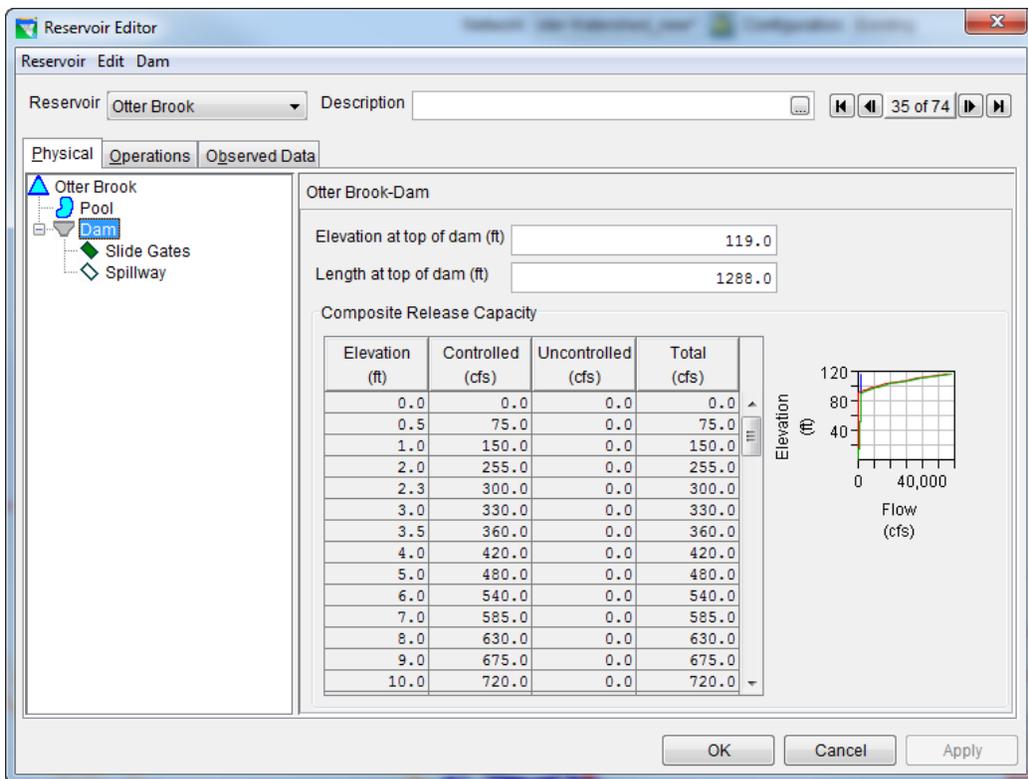


Figure 4: Reservoir Editor: Physical Tab -- Dam



## B. Rule Illustrations

Figure 6 shows a set of operational rules specified for each zone that reflects the operation set named Existing Ops. As described in the Simulation/Verification section of the report, adjustments were made to the operations to closer match gauge data.

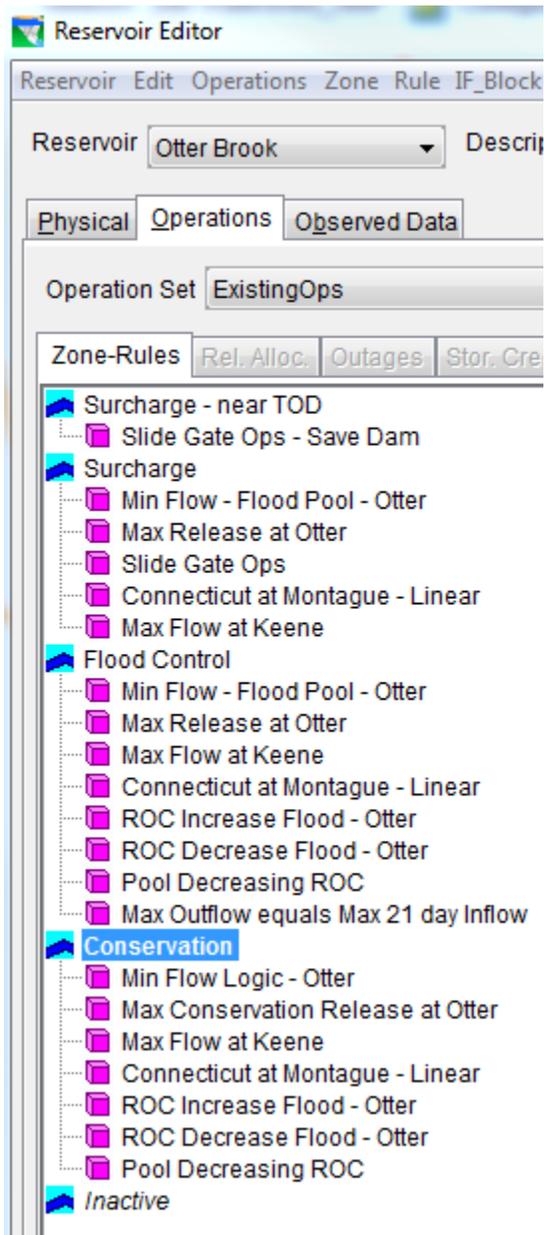


Figure 6: Reservoir Editor: Operations Tab – Existing Ops OpSet – Zones and Rules

## C. Rule Descriptions

### 1. Slide Gate Ops-Save Dam

Figure 7 shows the content of “Slide Gate Ops-Save Dam” rule. This rule represents the maximum allowable release from Slide gates as a function of pool elevation when the pool is in Surcharge-near TOD zone.

The screenshot shows the 'Slide Gate Ops-Save Dam' rule configuration in the Reservoir Editor. The 'Function of' is set to 'Pool Elevation, Period Average, 0.0 hr lag, 48.0 hr period'. The 'Limit Type' is 'Maximum' and 'Interp.' is 'Linear'. The table below shows the release limits for different elevations.

Elev (ft)	Release (cfs)
109.0	0.0
112.0	1200.0
114.0	2400.0
119.0	2400.0

The graph on the right shows the release rate (cfs) as a function of elevation (ft). The release rate is 0 cfs at 109 ft, increases linearly to 1200 cfs at 112 ft, then to 2400 cfs at 114 ft, and remains constant at 2400 cfs up to 119 ft.

Additional configuration options include:

- Period Average Limit (Edit...)
- Hour of Day Multiplier (Edit...)
- Day of Week Multiplier (Edit...)
- Rising/Falling Condition (Edit...)
- Seasonal Variation (Edit...)

Figure 7: Reservoir Editor: Operations Tab – Existing Ops OpSet – Slide Gate Ops-Save Dam

### 2. Min Flow-Flood Pool-Otter

Figure 8 shows the content of “Min Flow-Flood Pool-Otter” rule. This rule shows the required minimum release from dam during flood control operations.

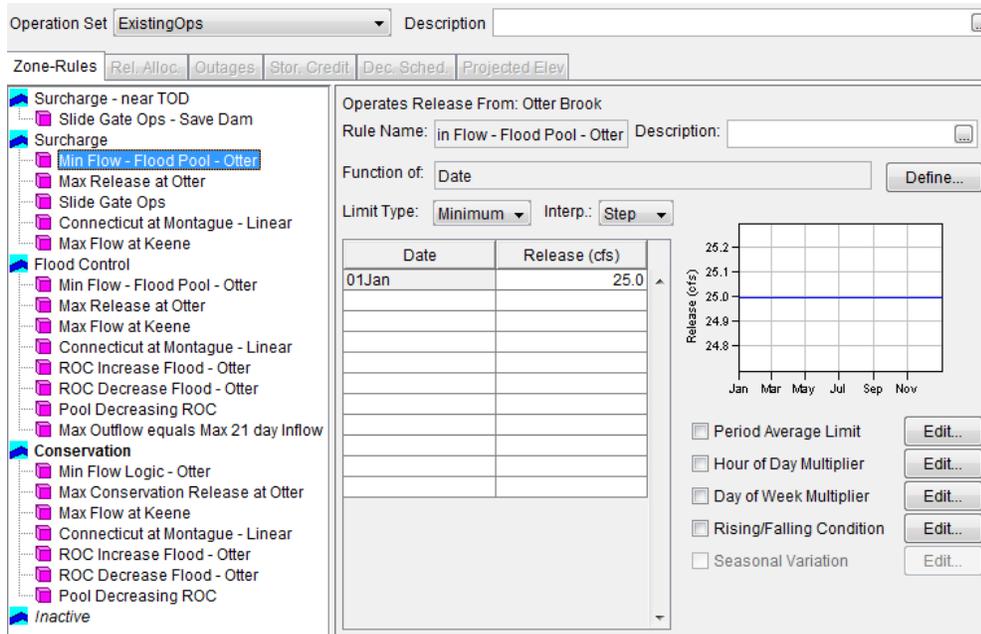


Figure 8: Reservoir Editor: Operations Tab – Existing Ops OpSet – Min Flow-Flood Pool-Otter

### 3. Max Release at Otter

Figure 9 shows the content of “Max Release at Otter” rule. This rule shows the maximum allowable release from dam.

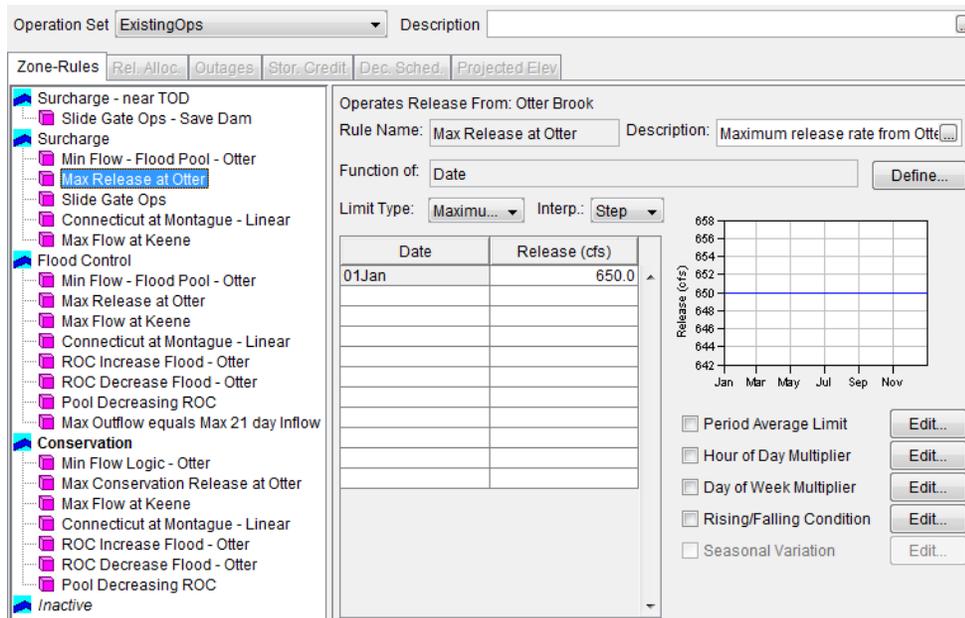


Figure 9: Reservoir Editor: Operations Tab – Existing Ops OpSet – Max Release at Otter

#### 4. Slide Gate Ops

Figure 10 shows the content of “Slide Gate Ops” rule. This rule represents the maximum allowable release from Slide gates as a function of pool elevation when the pool is in Surcharge zone.

The screenshot shows the 'Slide Gate Ops' rule configuration in the Reservoir Editor. The 'Function of' field is set to 'Pool Elevation, Period Average, 0.0 hr lag, 48.0 hr period'. The 'Limit Type' is 'Maximum' and the 'Interp.' is 'Line'. A table shows the release rates for different elevations, and a graph plots Release (cfs) against Elevation (ft).

Elev (ft)	Release (cfs)
89.0	650.0
89.975	0.0
109.0	0.0
112.0	1200.0
114.0	2400.0
119.0	2400.0

Figure 10: Reservoir Editor: Operations Tab – Existing Ops OpSet – Slide Gate Ops

### 5. Connecticut at Montague-Linear

Figure 11 shows the content of “Connecticut at Montague-Linear” rule. This rule represents the maximum allowable release from the dam as a function of the previous day stage at Montague. The previous day stage was used to account for the delay that occurs between the stage exceeding the specified target and the change in operations at the flood control dams that occurs in reality.

Operates Release From: Otter Brook

Rule Name:  Description:

Function of:

Limit Type:  Interp.:

Stage (ft)	Release (cfs)
0.0	650.0
25.0	650.0
26.0	520.0
27.0	390.0
28.0	260.0
29.0	130.0
30.0	0.0
50.0	0.0

Release (cfs) vs Stage (ft) graph showing a step-down function.

Period Average Limit

Hour of Day Multiplier

Day of Week Multiplier

Rising/Falling Condition

Seasonal Variation

Figure 11: Reservoir Editor: Operations Tab – Existing Ops OpSet – Connecticut at Montague-Linear

### 6. Max Flow at Keene

Figure 12 shows the content of “Max Flow at Keene” rule. This rule represents the maximum allowable flow downstream at the point Ashuelot+Otter Brook.

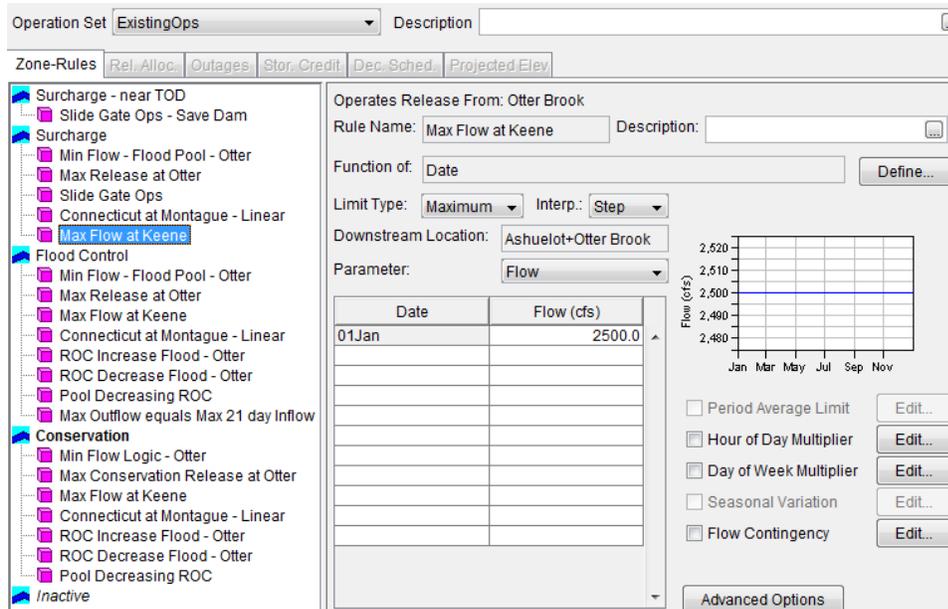


Figure 12: Reservoir Editor: Operations Tab – Existing Ops OpSet – Max flow at Keene

### 7. ROC Increase Flood-Otter

Figure 13 shows the content of “ROC Increase Flood-Otter” rule. This rule shows the maximum allowable increasing release rate of change as a function of release from Otter Brook dam.

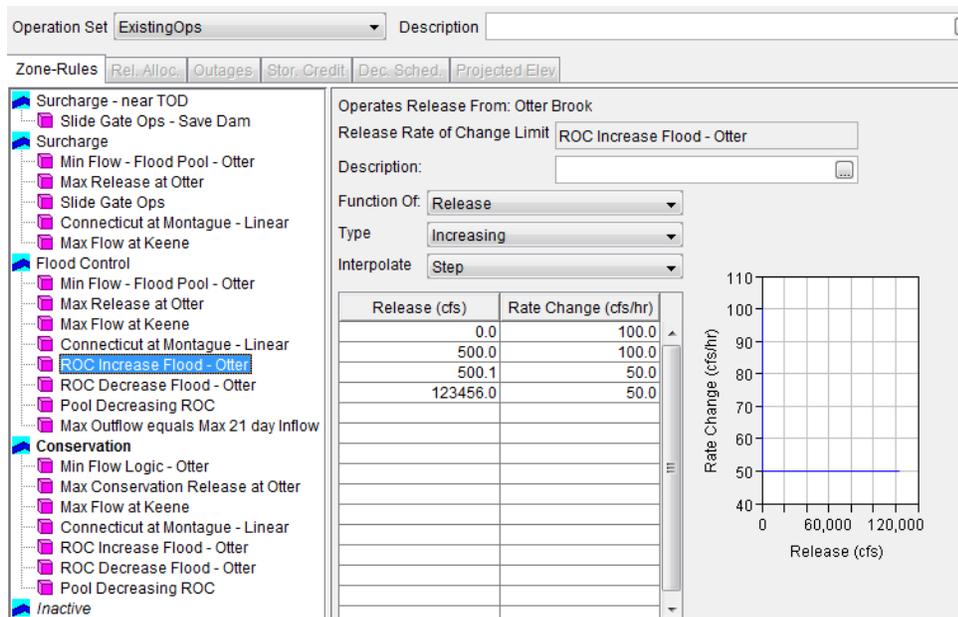


Figure 13: Reservoir Editor: Operations Tab – Existing Ops OpSet – ROC Increase Flood-Otter

### 8. ROC Decrease Flood-Otter

Figure 14 shows the content of “ROC Decrease Flood-Otter” rule. This rule shows the maximum allowable decreasing release rate of change.

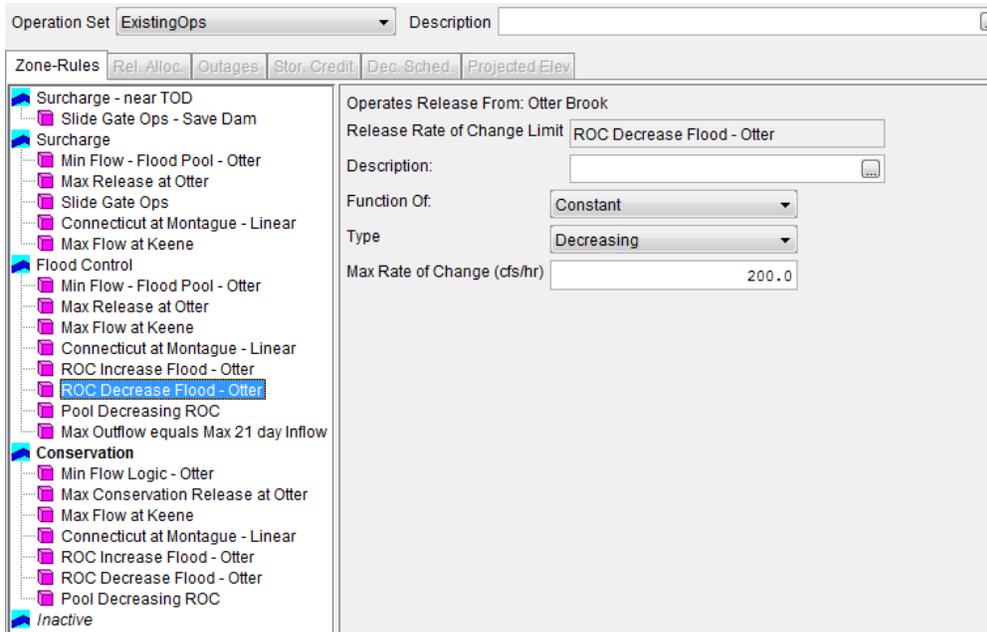


Figure 14: Reservoir Editor: Operations Tab – Existing Ops OpSet – ROC Decrease Flood-Otter

### 9. Pool Decreasing ROC

Figure 15 shows the content of “Pool Decreasing ROC” rule. This rule shows the maximum allowable decreasing pool elevation rate of change.

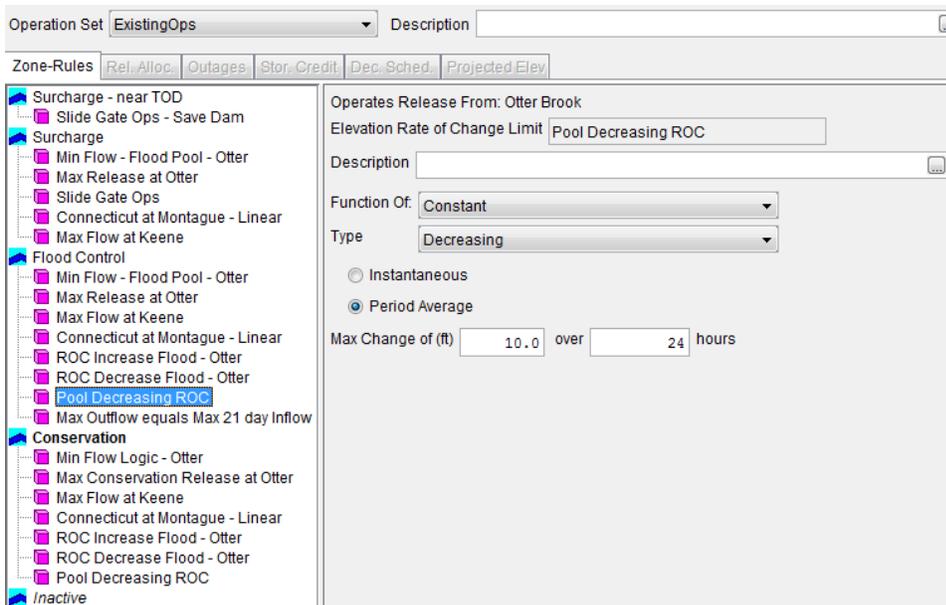


Figure 15: Reservoir Editor: Operations Tab – Existing Ops OpSet – Pool Decreasing ROC

### 10. Max Outflow equals Max 21 day Inflow

Figure 16 shows the content of “Max outflow equals Max 21 day Inflow” rule. This rule represents the maximum release from dam as a function of the previous 3 weeks of inflow.

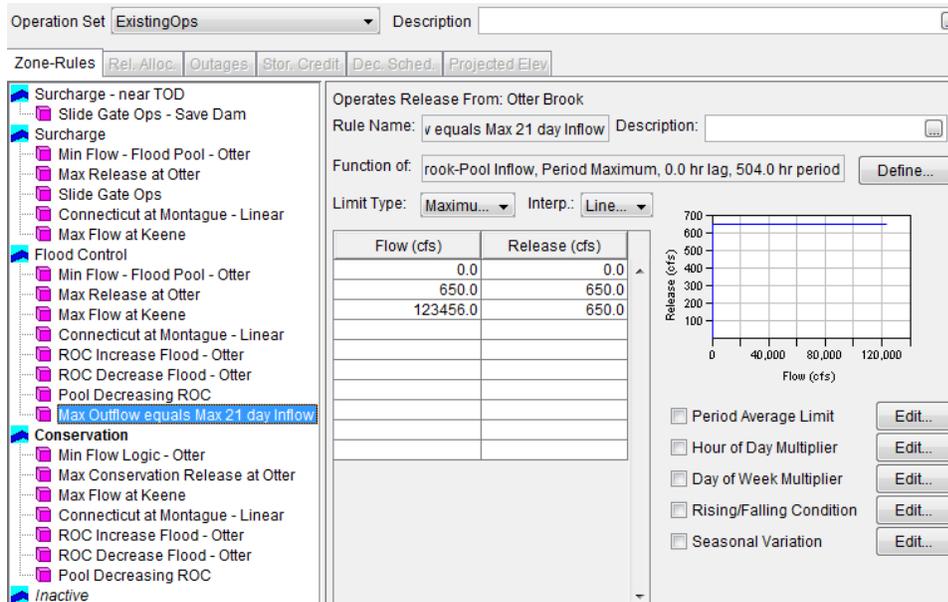


Figure 16: Reservoir Editor: Operations Tab – Existing Ops OpSet – Max Outflow equals Max 21 day Inflow

### 11. Min Flow Logic-Otter

Figure 17 shows the content of “Min flow Logic-Otter” rule. This rule provides seasonal minimum releases from Otter Brook as a function of inflow.

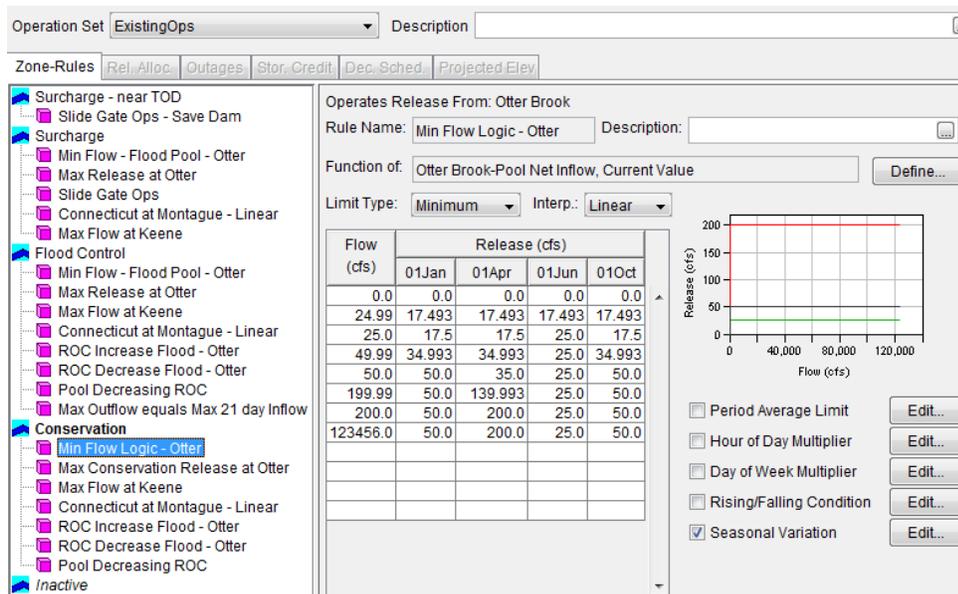


Figure 17: Reservoir Editor: Operations Tab – Existing Ops OpSet – Min Flow Logic-Otter

## Power Canal (Turners Falls)

### I. Overview

Power Canal dam is one of the outlet canals from Turners Falls that is used for hydropower generation. It is part of the Turners Falls project but is modeled separately in the ResSim model because Gomez and Sullivan Engineers P.C., modeled it in this fashion.

Figure 1 shows the location of Power Canal Dam as it is represented in the HEC-ResSim model.

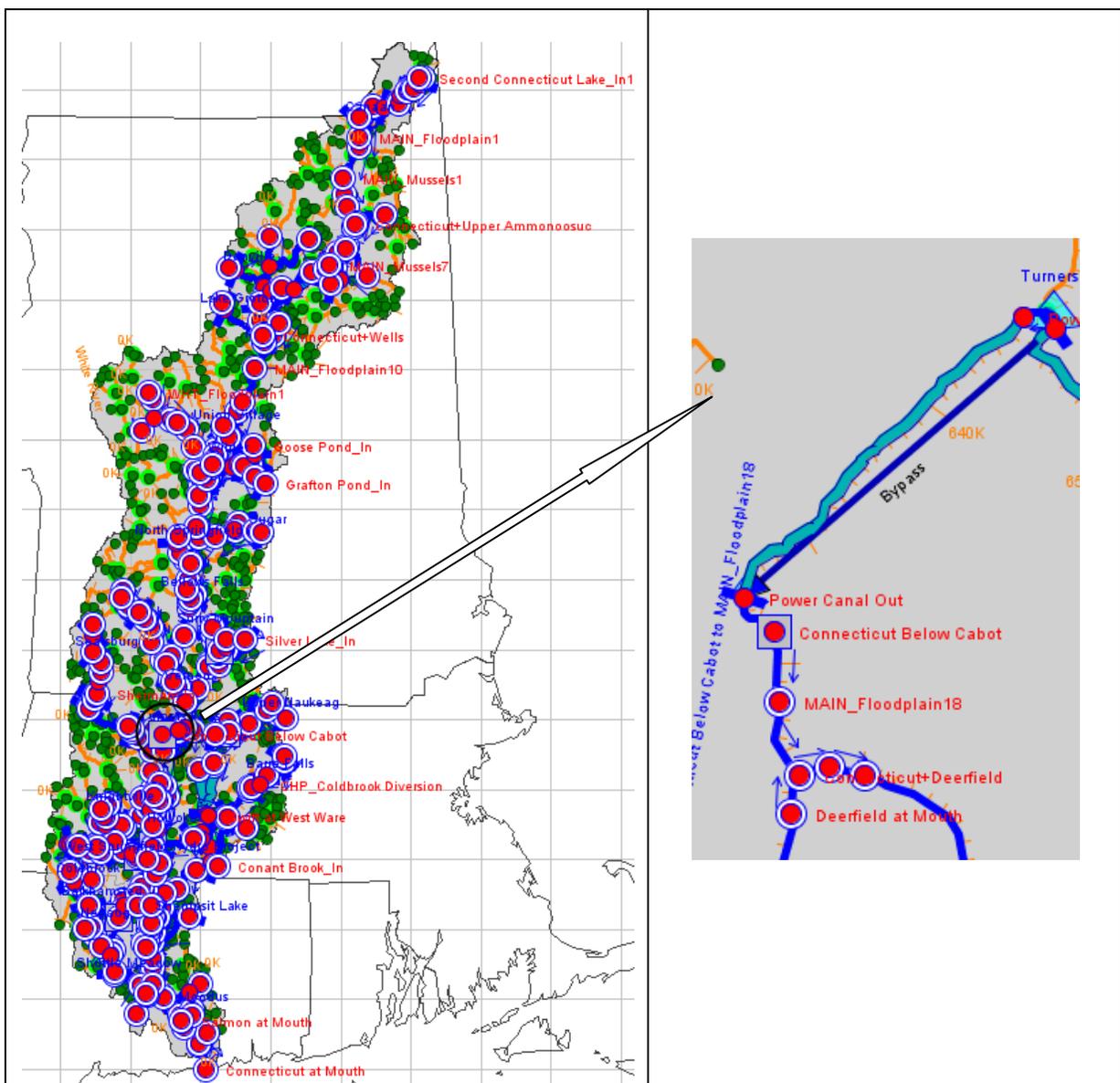


Figure 1: HEC-ResSim Map Display Showing Location of Power Canal dam



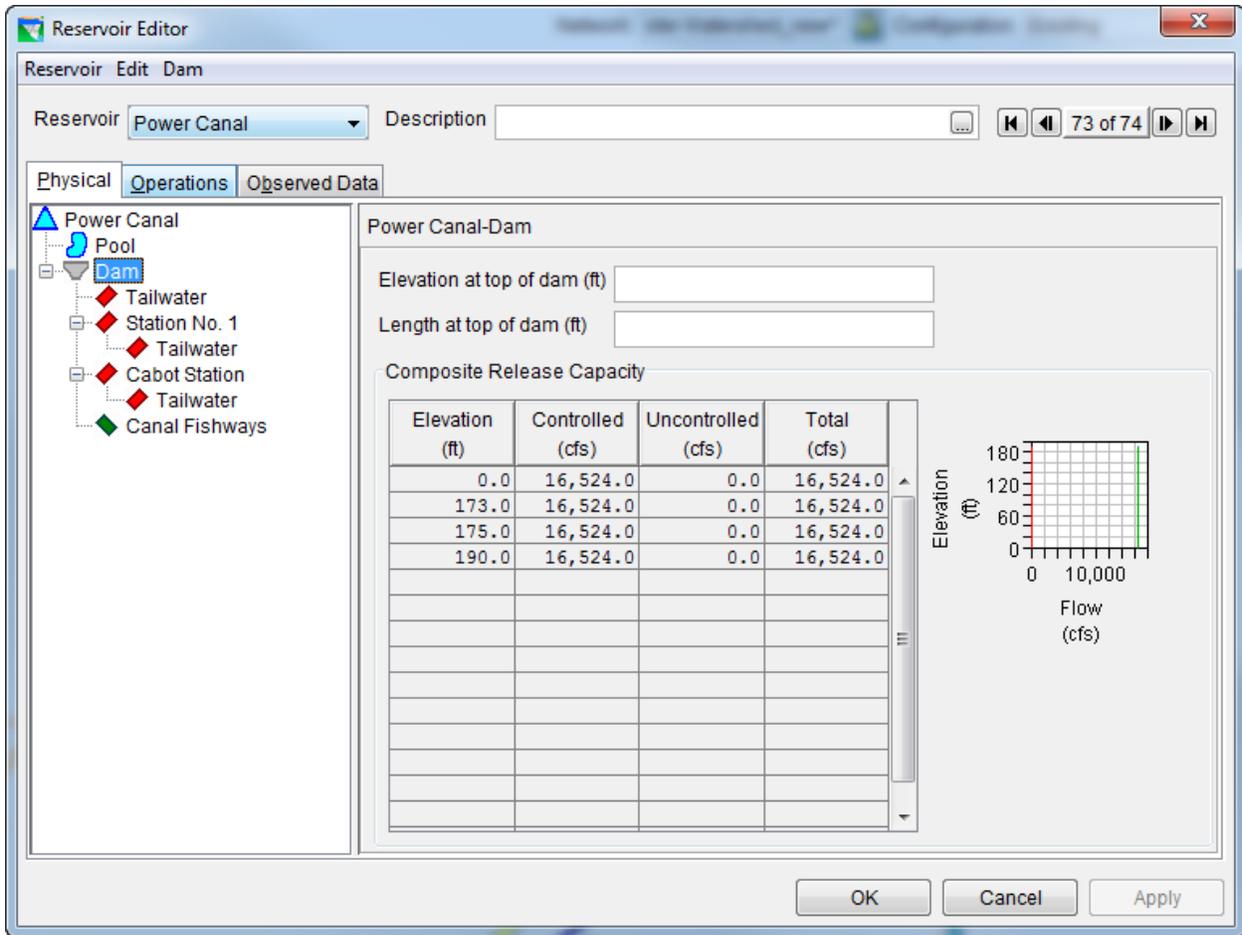


Figure 3: Reservoir Editor: Physical Tab -- Dam



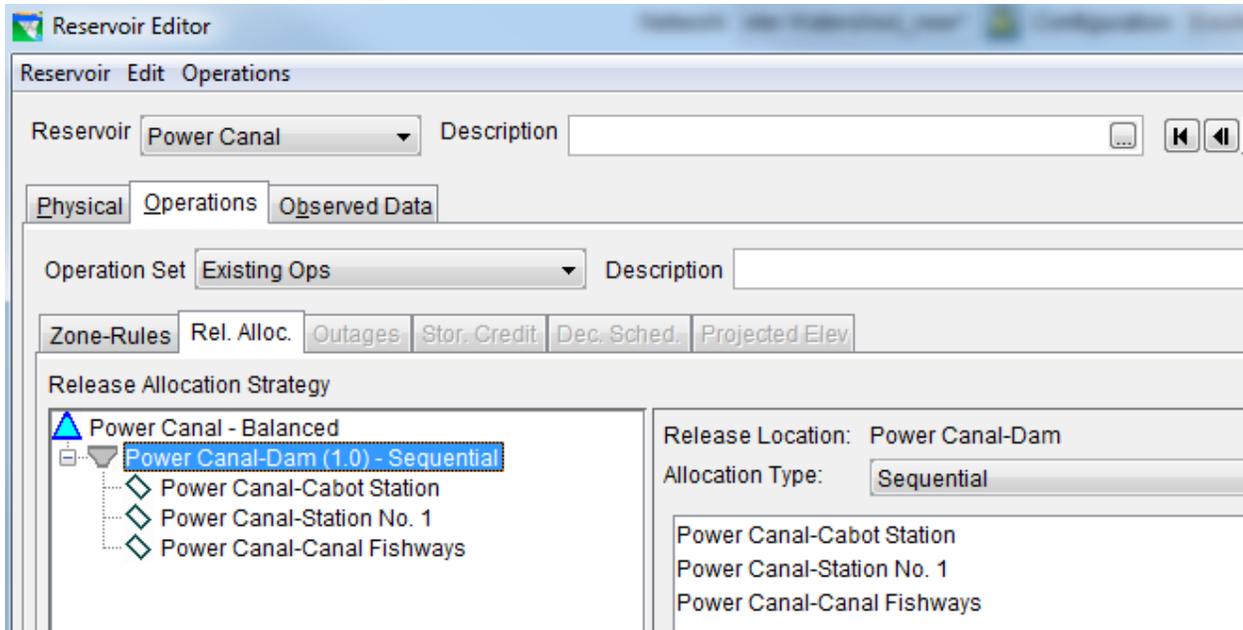


Figure 5: Reservoir Editor: Operations Tab – Existing Ops OpSet – Release Allocation

## B. Rule Illustrations

Figure 6 shows a set of operational rules specified for each zone that reflects the operation set named Existing Ops.

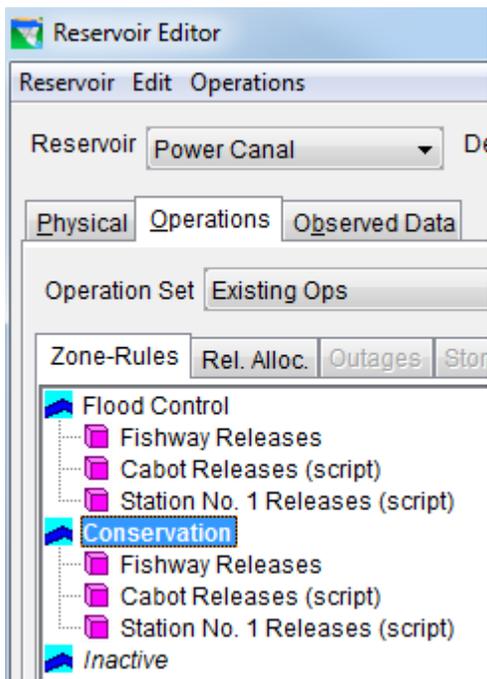


Figure 6: Reservoir Editor: Operations Tab – Existing Ops OpSet – Zones and Rules

## C. Rule Descriptions

### 1. Fishway Release

Figure 7 shows the content of “Fishway Release” rule. It shows the sum of Cabot ladder attraction flow and fishway flow, spillway ladder fishway flow (not attraction flow which releases from spillway gates), and Cabot log sluice for downstream fish passage. Gatehouse ladder attraction flow and fishway flow release to the canal and are available for generation so are not included here. Values of 386 cfs include the cabot and spillway ladders, values of 586 cfs include those two ladders plus the Cabot log sluice, and values of 200 cfs include the log sluice only.

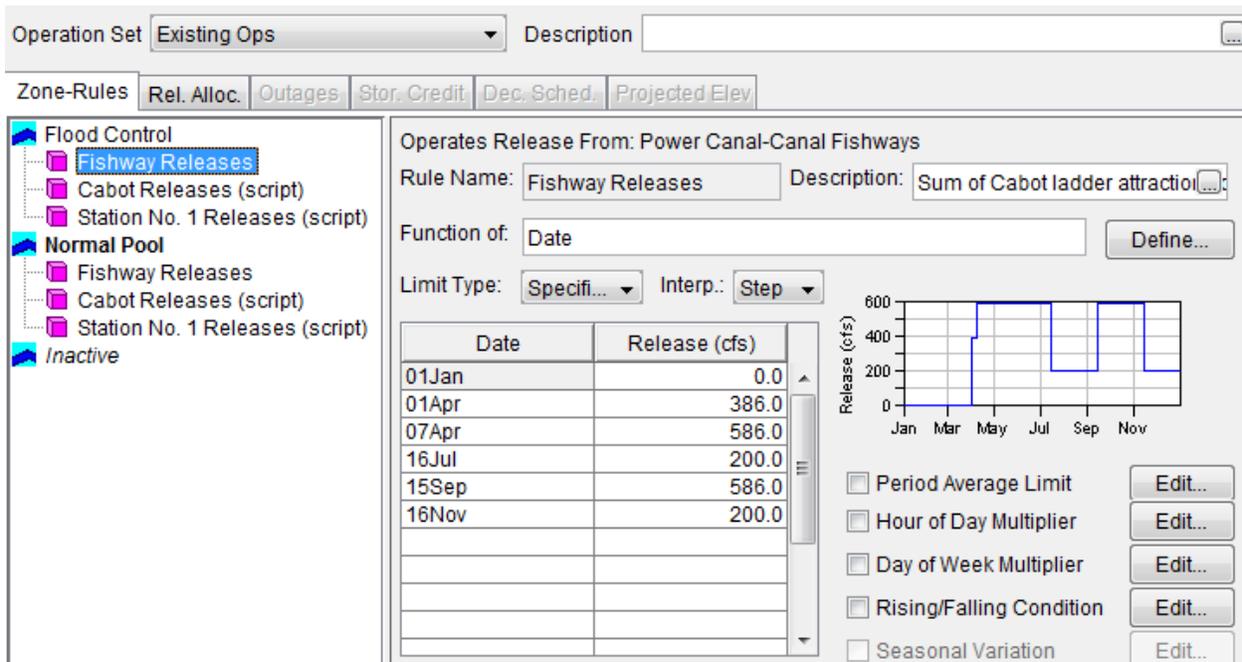


Figure 7: Reservoir Editor: Operations Tab – Existing Ops OpSet – Fishway Release

## 2. Cabot Release(script)

Figure 8 shows the content of “Cabot Release” rule. This script calculates the Power Canal's inflow and subtracts the seasonal fishways flow to determine how much flow should be released through Cabot Station. 1400 cfs corresponds to the minimum flow to run one unit at Cabot; 13,728 cfs is Cabot's capacity.

The screenshot displays the 'Operations Tab' for the 'Existing Ops' OpSet. The 'Cabot Releases (script)' rule is selected, and its description is: "This script calculates the Power Canal's inflow and subtracts the seasonal fishways flow". The script code is as follows:

```

13 # create new Operation Value (OpValue) to return
14 opValue = OpValue()
15
16 # This script calculates the Power Canal's inflow and subtracts the seasonal
17 # fishways flow to determine how much flow should be released through Cabot Station.
18 # 1400 cfs corresponds to the minimum flow to run one unit at Cabot; 13,728 cfs is Cabot's capacity.
19
20 # Calculate the power canal's effective inflow (inflow - fishway release)
21 canal_inflow = network.getTimeSeries("Reservoir","Power Canal", "Pool", "Flow-IN NET").getCurrentValue(currentRuntimestep)
22 fishway_outflow = network.getTimeSeries("Reservoir","Power Canal", "Canal Fishways-Fishway Releases", "Flow-SPEC").getCurrentValue(currentRuntimestep)
23 effective_inflow = canal_inflow - fishway_outflow
24
25 #cabot_minflow = 1400
26 #cabot_capacity = 13728
27
28 # set type and value for OpValue
29 # type is one of:
30 # OpRule.RULETYPE_MAX - maximum flow
31 # OpRule.RULETYPE_MIN - minimum flow
32 # OpRule.RULETYPE_SPEC - specified flow
33 if effective_inflow < 1400:
34     opValue.init(OpRule.RULETYPE_SPEC, 0)
35 elif effective_inflow <= 13728:
36     opValue.init(OpRule.RULETYPE_SPEC, effective_inflow)
37 else:
38     opValue.init(OpRule.RULETYPE_SPEC, 13728)
39
40 # return the Operation Value.
41 # return "None" to have no effect on the compute
42 return opValue

```

Figure 8: Reservoir Editor: Operations Tab – Existing Ops OpSet – Cabot Release

### 3. Station No.1 Releases(script)

Figure 9 shows the content of “Station No.1 Releases” rule. This script calculates the Power Canal's inflow and subtracts the seasonal fishways flow to determine how much flow should be released through Station No. 1. 1400 cfs corresponds to the minimum flow to run one unit at Cabot; 13,728 cfs is Cabot's capacity.

```

13  # create new Operation Value (OpValue) to return
14  opValue = OpValue()
15
16  # This script calculates the Power Canal's inflow and subtracts the seasonal
17  # fishways flow to determine how much flow should be released through Station No. 1.
18  # 1400 cfs corresponds to the minimum flow to run one unit at Cabot; 13,728 cfs is Cabot's capacity.
19
20  # Calculate the power canal's effective inflow (inflow - fishway release)
21  canal_inflow = network.getTimeSeries("Reservoir","Power Canal", "Pool", "Flow-IN NET").getCurrentValue(currentRuntimestep)
22  fishway_outflow = network.getTimeSeries("Reservoir","Power Canal", "Canal Fishways-Fishway Releases", "Flow-SPEC").getCurrentValue(currentRuntimestep)
23  effective_inflow = canal_inflow - fishway_outflow
24
25  #cabot_minflow = 1400
26  #cabot_capacity = 13728
27
28  # set type and value for OpValue
29  # type is one of:
30  # OpRule.RULETYPE_MAX - maximum flow
31  # OpRule.RULETYPE_MIN - minimum flow
32  # OpRule.RULETYPE_SPEC - specified flow
33  if effective_inflow < 1400:
34      opValue.init(OpRule.RULETYPE_SPEC, effective_inflow)
35  elif effective_inflow > 13728:
36      opValue.init(OpRule.RULETYPE_SPEC, effective_inflow - 13728)
37  else:
38      opValue.init(OpRule.RULETYPE_SPEC, 0)
39
40  # return the Operation Value.
41  # return "None" to have no effect on the compute
42  return opValue

```

Figure 9: Reservoir Editor: Operations Tab – Existing Ops OpSet – Station No.1 Releases(script)

# Quabbin Windsor

## I. Overview

The Quabbin Windsor dam is a very large project located on the Swift River that feeds into the Chicopee River. It is owned and operated by the Massachusetts Water Resources Authority (MWRA) and is used for water supply for the City of Boston.

Figure 1 shows the location of Quabbin Windsor dam as it is represented in the HEC-ResSim model. Figure 2 show a photo of Quabbin Windsor dam.

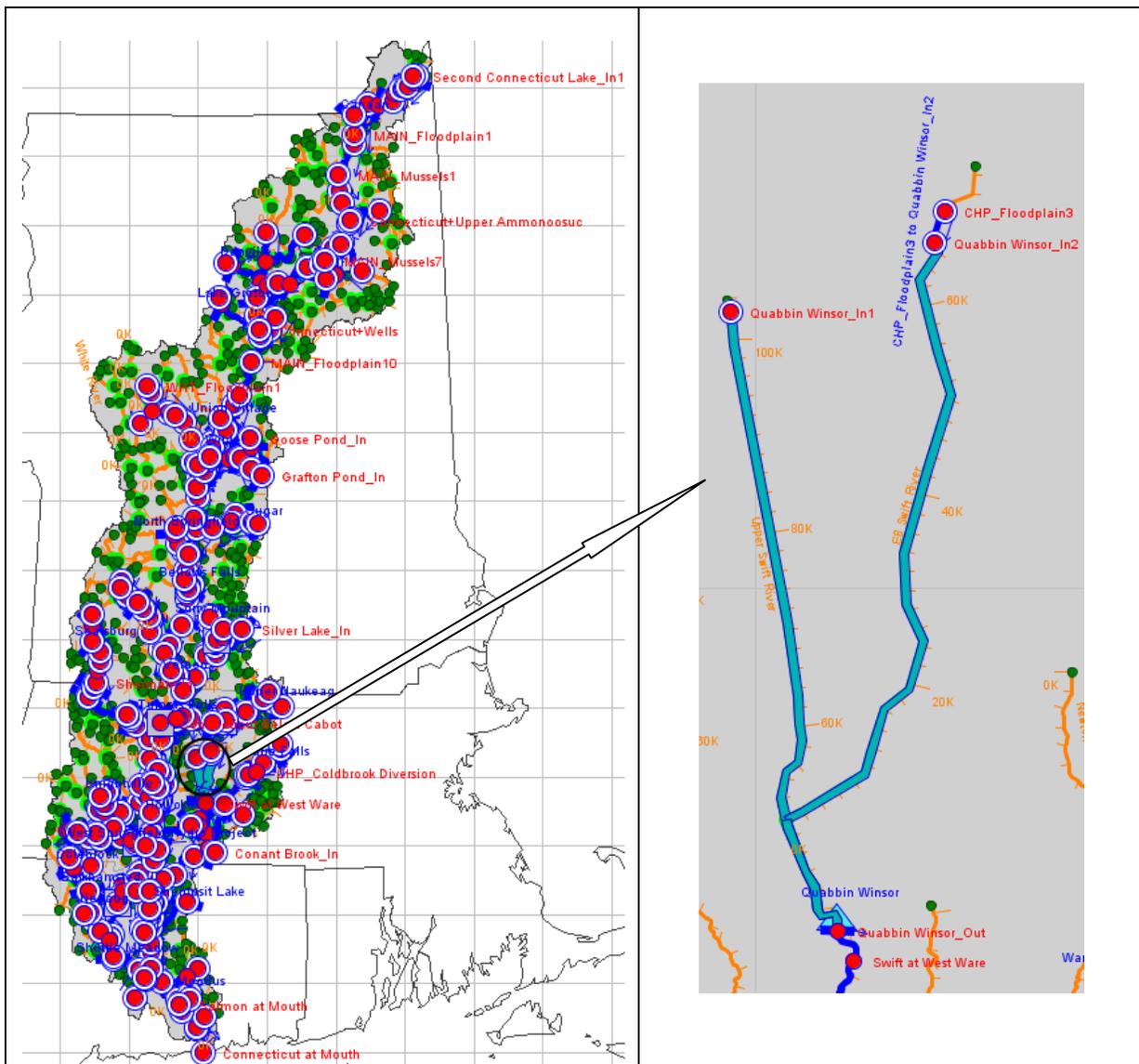


Figure 1: HEC-ResSim Map Display Showing Location of Quabbin dam



Figure 2: Photo of Quabbin Windsor dam.

## II. Physical Characteristics

The physical characteristics of the reservoir are separated between the Pool and the Dam in the HEC-ResSim model. The elevation-storage-area defines the pool as shown in Figure 3<sup>79</sup>. The dam consists of three types of outlets: (1) controlled Bypass to Swift River, (2) uncontrolled spillway, (3) uncontrolled Auxillary Spillway as shown in Figure 4.

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<sup>79</sup> Phase I Report. 1978.

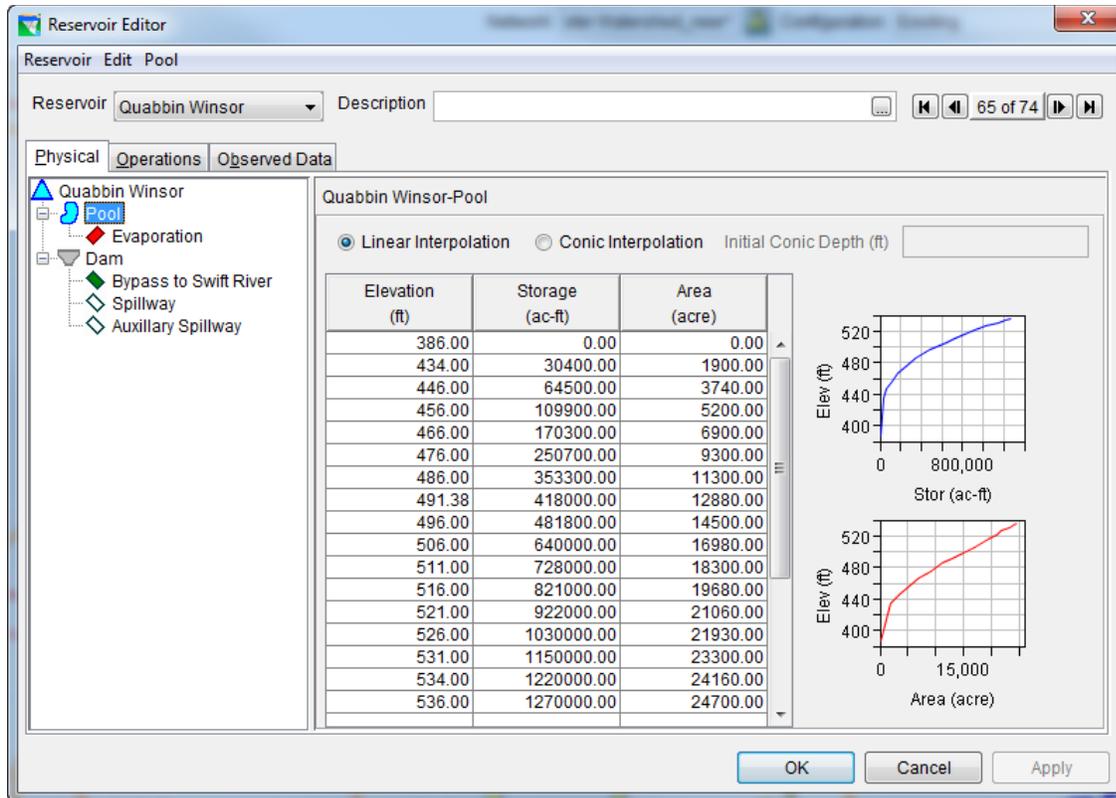


Figure 3: Reservoir Editor: Physical Tab -- Pool

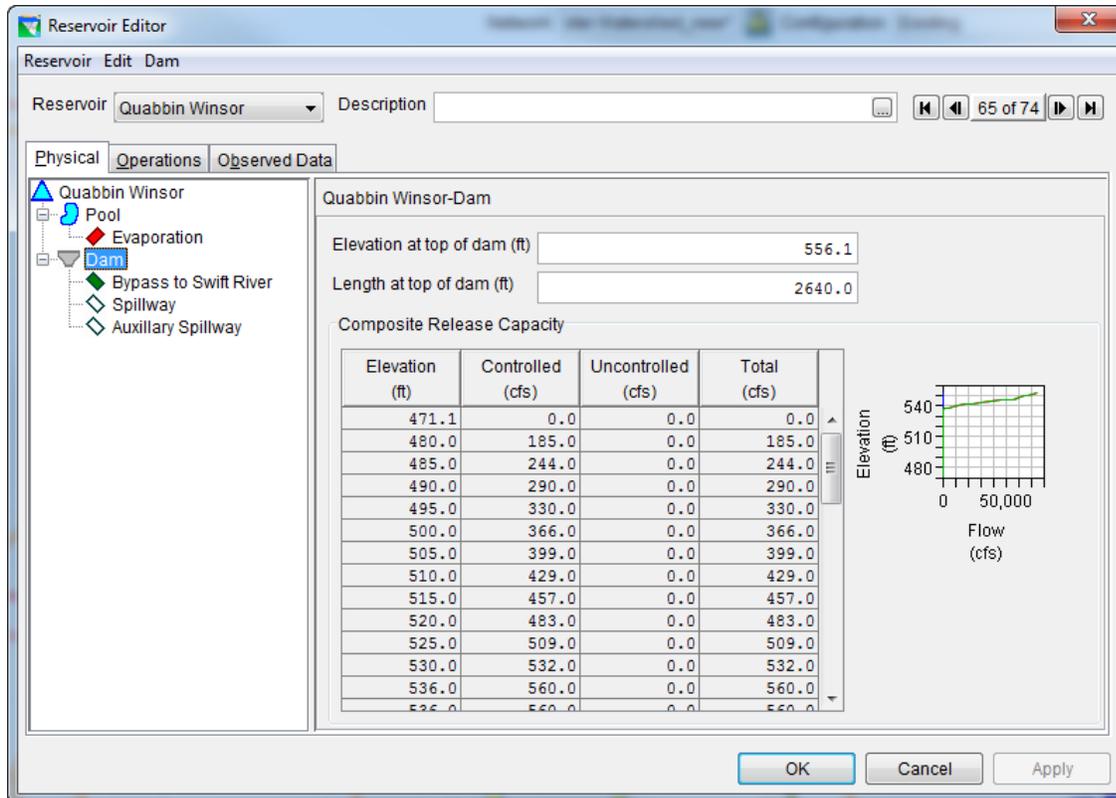
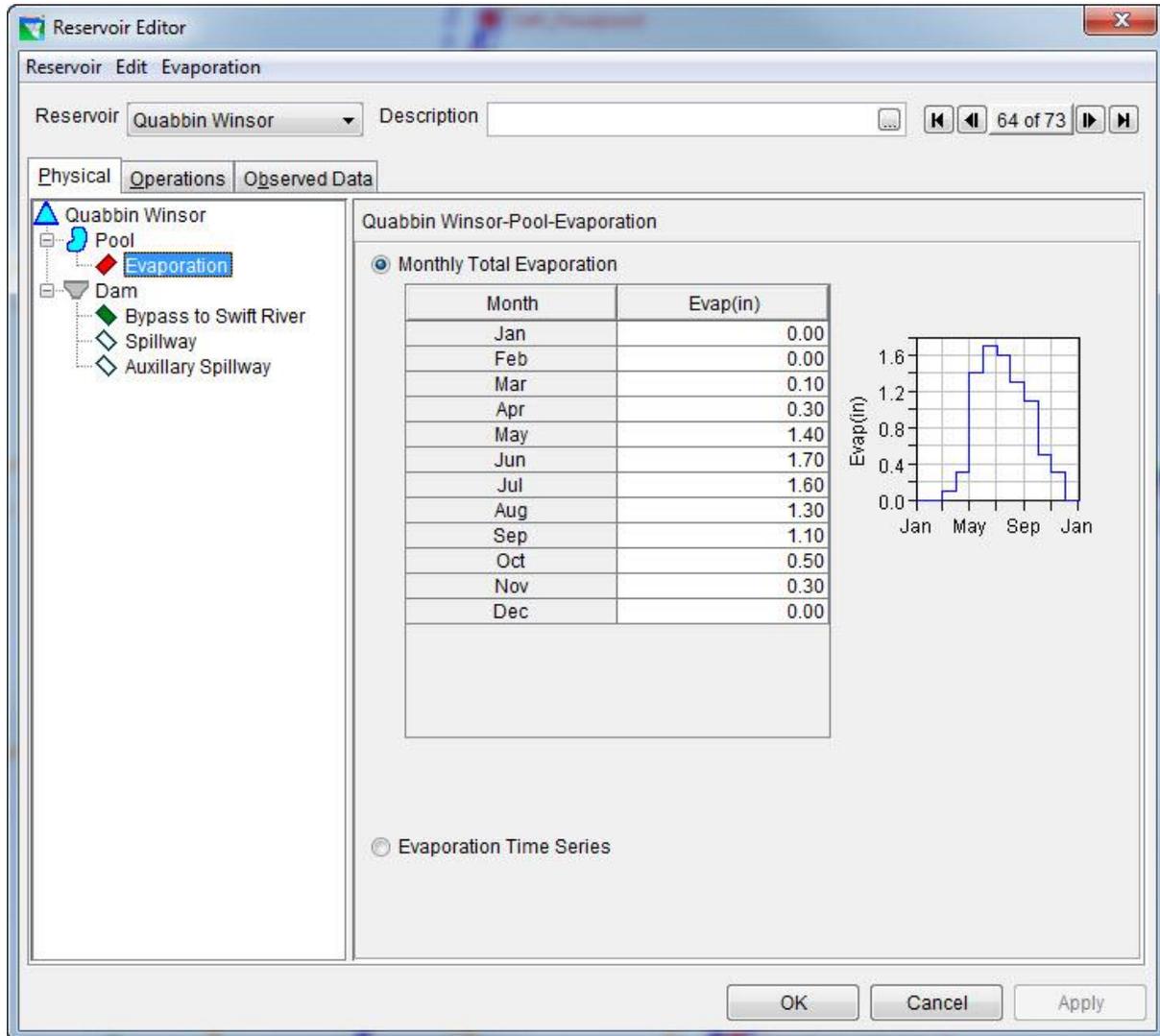


Figure 4: Reservoir Editor: Physical Tab -- Dam

Figure 5 shows the monthly evaporation factors that were accounted for Quabbin Windsor, due to the large size of the reservoir.





## B. Rule Illustrations

Figure 6 shows a set of operational rules specified for each zone that reflects the operation set named Existing Ops<sup>1</sup>. Quabbin, the largest reservoir in the basin and one of the major water supply sources for the City of Boston, had its water withdrawals estimated from a combination of monthly pool levels and annual water supply volumes from 2006 to 2009, provided by the Massachusetts Water Resources Authority's (MWRA) website and the Massachusetts Department of Environmental Protection (MADEP), which showed the pool is allowed to fluctuate seasonally. Gauged records of discharges from Quabbin and SYE flows gave some indication of the total volume that was diverted from the reservoir for water supply. These different facets were used to crudely estimate a withdrawal time series for the model period of record. The main goal was to remove a significant percentage of the total volume released from Quabbin into the Swift River. It is worth noting that in the mid 1980s, significant reductions in water supply demand as well as fixes to the system such as repairing leaking pipes began to be implemented that reduced the withdrawals from Quabbin. This is reflected in the water supply time series for Quabbin.

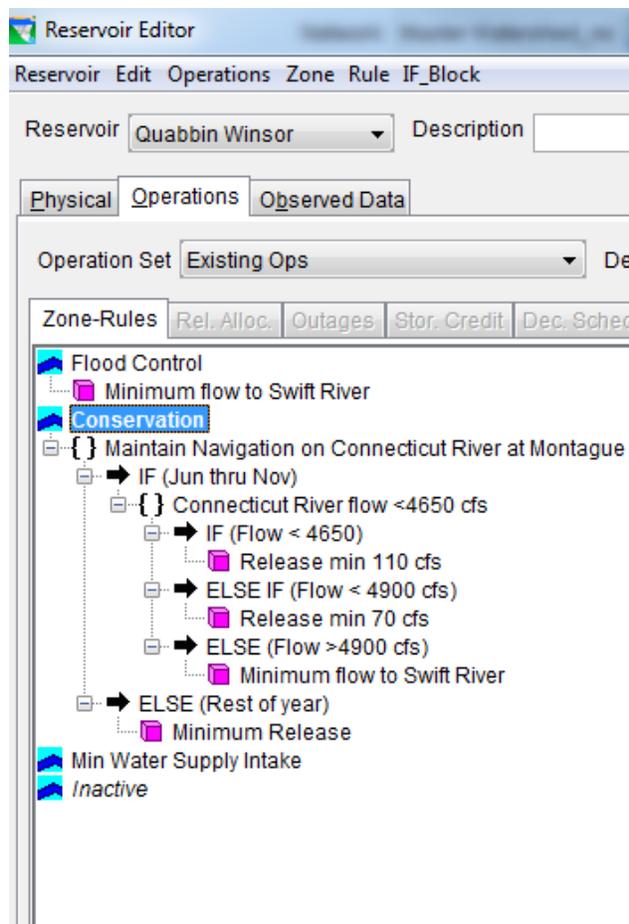


Figure 6: Reservoir Editor: Operations Tab – Existing Ops OpSet – Zones and Rules

## C. Rule Descriptions

### 1. Minimum flow to Swift River

Figure 7 shows the content of “Minimum flow to Swift River” rule. This rule shows a minimum flow from dam to swift river.

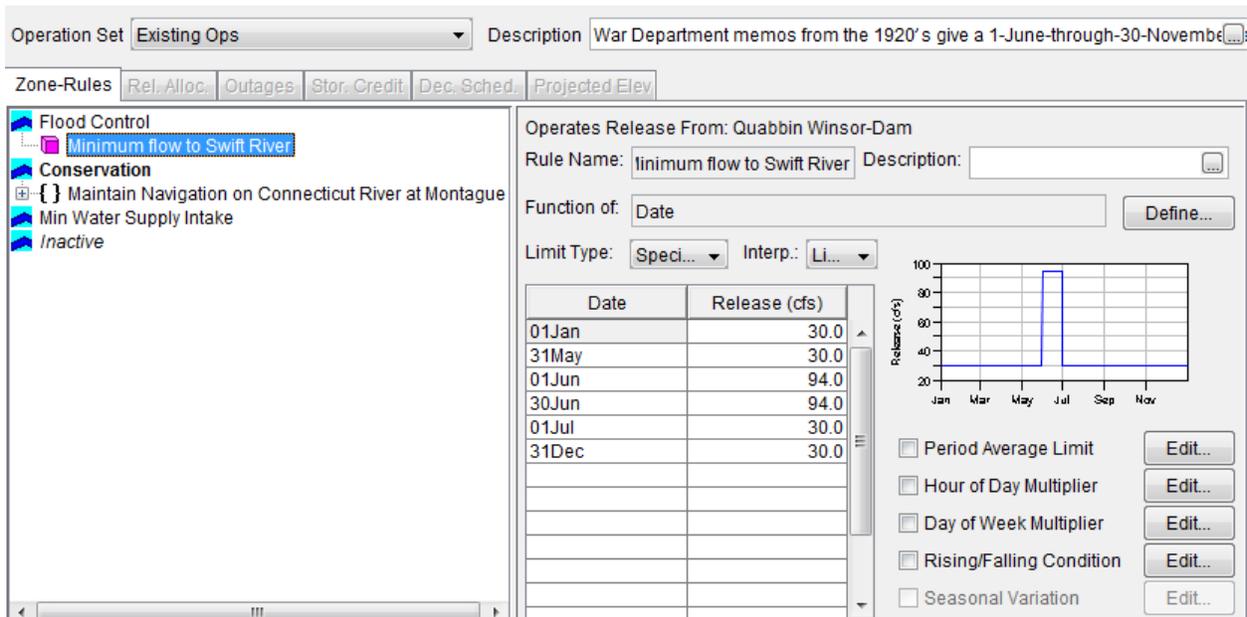


Figure 7: Reservoir Editor: Operations Tab – Existing Ops OpSet – Minimum flow to Swift River

## 2. Maintain Navigation on Connecticut River at Montague

Figure 8 shows the content of “Maintain Navigation on Connecticut River at Montague” rule. This rule shows a minimum release from dam as a function of Inflow during Jun-Nov.

The screenshot displays a software interface for configuring a rule. The top section shows the 'Operation Set' as 'Existing Ops' and the 'Description' as 'War Department memos from the 1920's give a 1-June-through-30-Novembe...'. Below this, there are tabs for 'Zone-Rules', 'Rel. Alloc.', 'Outages', 'Stor. Credit', 'Dec. Sched.', and 'Projected Elev.'. The left pane shows a tree view of rules under 'Conservation', with 'Maintain Navigation on Connecticut River at Montague' selected. The right pane shows the configuration for this rule, including 'Operates Release From: Quabbin Winsor-Dam' and 'IF Conditional: Jun thru Nov'. A table below the configuration shows conditions for 'Value1' and 'Value2' with logical operators '>=' and '<='.

	Value1		Value2
	Current Time Step	>=	01Jun
AND	Current Time Step	<=	30Nov

The bottom section of the screenshot shows the same interface but with the 'Name' field set to 'Connecticut River flow <4650 cfs'. A table below shows the conditions for this rule:

Type	Name	Description
IF	Flow < 4650	
ELSE IF	Flow < 4900 cfs	
ELSE	Flow >4900 cfs	

Operation Set Existing Ops
Description War Department memos from the 1920's give a 1-June-through-30-Novembe...

Zone-Rules Rel. Alloc. Outages Stor. Credit Dec. Sched. Projected Elev.

- Flood Control
  - Minimum flow to Swift River
- Conservation
  - Maintain Navigation on Connecticut River at Montague
    - IF (Jun thru Nov)
      - Connecticut River flow <4650 cfs
        - IF (Flow < 4650)**
          - Release min 110 cfs
        - ELSE IF (Flow < 4900 cfs)
          - Release min 70 cfs
        - ELSE (Flow >4900 cfs)
          - Minimum flow to Swift River
      - ELSE (Rest of year)
        - Minimum Release
- Min Water Supply Intake
- Inactive

Operates Release From: Quabbin Winsor-Dam

IF Conditional Flow < 4650 Description:

Value1	Value2
Connecticut at Montague:Flow	< 4650

Logical Operator:

Value 1 Constant

Ope...

Value 2 Constant

---

Operation Set Existing Ops
Description War Department memos from the 1920's give a 1-June-through-30-Novembe...

Zone-Rules Rel. Alloc. Outages Stor. Credit Dec. Sched. Projected Elev.

- Flood Control
  - Minimum flow to Swift River
- Conservation
  - Maintain Navigation on Connecticut River at Montague
    - IF (Jun thru Nov)
      - Connecticut River flow <4650 cfs
        - IF (Flow < 4650)
          - Release min 110 cfs**
        - ELSE IF (Flow < 4900 cfs)
          - Release min 70 cfs
        - ELSE (Flow >4900 cfs)
          - Minimum flow to Swift River
      - ELSE (Rest of year)
        - Minimum Release
  - Min Water Supply Intake
  - Inactive

Operates Release From: Quabbin Winsor-Dam

Rule Name: Release min 110 cfs Description:

Function of: Date

Limit Type: Mini... Interp.: Li...

Date	Release (cfs)
01Jan	110.0



Period Average Limit   
 Hour of Day Multiplier   
 Day of Week Multiplier   
 Rising/Falling Condition   
 Seasonal Variation

Operation Set: Existing Ops Description: War Department memos from the 1920's give a 1-June-through-30-Novembe...

Zone-Rules: Rel. Alloc. Outages Stor. Credit Dec. Sched. Projected Elev.

**Flood Control**

- Minimum flow to Swift River

**Conservation**

- Maintain Navigation on Connecticut River at Montague
  - IF (Jun thru Nov)
    - Connecticut River flow <4650 cfs
      - IF (Flow < 4650)
        - Release min 110 cfs
        - ELSE IF (Flow < 4900 cfs)**
        - Release min 70 cfs
        - ELSE (Flow >4900 cfs)
          - Minimum flow to Swift River
    - ELSE (Rest of year)
      - Minimum Release
- Min Water Supply Intake
- Inactive

Operates Release From: Quabbin Winsor-Dam

ELSE IF Conditional: Flow < 4900 cfs Description: ...

	Value1		Value2
	Connecticut at Montague:Flow	>=	4650
AND	Connecticut at Montague:Flow	<	4900

Buttons: Add Cond., Del. Cond., Move Up, Move Down, Evaluate

Logical Operator: [v]

Value 1: Constant [ ]

Ope...: [v]

Value 2: Constant [ ]

---

Operation Set: Existing Ops Description: War Department memos from the 1920's give a 1-June-through-30-Novembe...

Zone-Rules: Rel. Alloc. Outages Stor. Credit Dec. Sched. Projected Elev.

**Flood Control**

- Minimum flow to Swift River

**Conservation**

- Maintain Navigation on Connecticut River at Montague
  - IF (Jun thru Nov)
    - Connecticut River flow <4650 cfs
      - IF (Flow < 4650)
        - Release min 110 cfs
        - ELSE IF (Flow < 4900 cfs)**
          - Release min 70 cfs**
        - ELSE (Flow >4900 cfs)
          - Minimum flow to Swift River
      - ELSE (Rest of year)
        - Minimum Release
  - Min Water Supply Intake
  - Inactive

Operates Release From: Quabbin Winsor-Dam

Rule Name: Release min 70 cfs Description: ...

Function of: Date Define...

Limit Type: Mini... Interp.: Li...

Date	Release (cfs)
01Jan	70.0

Options:
 

- Period Average Limit Edit...
- Hour of Day Multiplier Edit...
- Day of Week Multiplier Edit...
- Rising/Falling Condition Edit...
- Seasonal Variation Edit...

Operation Set: Existing Ops Description: War Department memos from the 1920's give a 1-June-through-30-Novembe...

Zone-Rules: Rel. Alloc. Outages Stor. Credit Dec. Sched. Projected Eley

**Flood Control**

- Minimum flow to Swift River

**Conservation**

- Maintain Navigation on Connecticut River at Montague
  - IF (Jun thru Nov)
    - Connecticut River flow <4650 cfs
      - IF (Flow < 4650)
        - Release min 110 cfs
      - ELSE IF (Flow < 4900 cfs)
        - Release min 70 cfs
      - ELSE (Flow >4900 cfs)
        - Minimum flow to Swift River
    - ELSE (Rest of year)
      - Minimum Release

Min Water Supply Intake

Inactive

Operates Release From: Quabbin Winsor-Dam

ELSE Conditional: Flow >4900 cfs Description:

---

Operation Set: Existing Ops Description: War Department memos from the 1920's give a 1-June-through-30-Novembe...

Zone-Rules: Rel. Alloc. Outages Stor. Credit Dec. Sched. Projected Eley

**Flood Control**

- Minimum flow to Swift River

**Conservation**

- Maintain Navigation on Connecticut River at Montague
  - IF (Jun thru Nov)
    - Connecticut River flow <4650 cfs
      - IF (Flow < 4650)
        - Release min 110 cfs
      - ELSE IF (Flow < 4900 cfs)
        - Release min 70 cfs
      - ELSE (Flow >4900 cfs)
        - Minimum flow to Swift River
    - ELSE (Rest of year)
      - Minimum Release

Min Water Supply Intake

Inactive

Operates Release From: Quabbin Winsor-Dam

Rule Name: Minimum flow to Swift River Description:

Function of: Date Define...

Limit Type: Speci... Interp.: Li...

Date	Release (cfs)
01Jan	30.0
31May	30.0
01Jun	94.0
30Jun	94.0
01Jul	30.0
31Dec	30.0

Period Average Limit Edit...  
 Hour of Day Multiplier Edit...  
 Day of Week Multiplier Edit...  
 Rising/Falling Condition Edit...  
 Seasonal Variation Edit...

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Operation Set: Existing Ops Description: War Department memos from the 1920's give a 1-June-through-30-Novembe...

Zone-Rules: Rel. Alloc. Outages Stor. Credit Dec. Sched. Projected Elev.

**Flood Control**

- Minimum flow to Swift River

**Conservation**

- Maintain Navigation on Connecticut River at Montague
  - IF (Jun thru Nov)
    - Connecticut River flow <4650 cfs
      - IF (Flow < 4650)
        - Release min 110 cfs
      - ELSE IF (Flow < 4900 cfs)
        - Release min 70 cfs
      - ELSE (Flow >4900 cfs)
        - Minimum flow to Swift River
    - ELSE (Rest of year)
      - Minimum Release

Min Water Supply Intake  
Inactive

Operates Release From: Quabbin Winsor-Dam

ELSE Conditional: Rest of year Description: ...

---

Operation Set: Existing Ops Description: War Department memos from the 1920's give a 1-June-through-30-Novembe...

Zone-Rules: Rel. Alloc. Outages Stor. Credit Dec. Sched. Projected Elev.

**Flood Control**

- Minimum flow to Swift River

**Conservation**

- Maintain Navigation on Connecticut River at Montague
  - IF (Jun thru Nov)
    - Connecticut River flow <4650 cfs
      - IF (Flow < 4650)
        - Release min 110 cfs
      - ELSE IF (Flow < 4900 cfs)
        - Release min 70 cfs
      - ELSE (Flow >4900 cfs)
        - Minimum flow to Swift River
    - ELSE (Rest of year)
      - Minimum Release

Min Water Supply Intake  
Inactive

Operates Release From: Quabbin Winsor

Rule Name: Minimum Release Description: ...

Function of: Date Define...

Limit Type: Mini... Interp.: Li...

Date	Release (cfs)
01Jan	30.0

Release (cfs) graph showing a constant value of 30.0 cfs from Jan to Nov.

- Period Average Limit Edit...
- Hour of Day Multiplier Edit...
- Day of Week Multiplier Edit...
- Rising/Falling Condition Edit...
- Seasonal Variation Edit...

Figure 8: Reservoir Editor: Operations Tab – Existing Ops OpSet – Maintain Navigation at Connecticut River at Montague

## Rainbow

### I. Overview

Rainbow Dam is located in the town of Rainbow, CT on the Farmington River. It is owned and operated by the Farmington River Power Company and is used for hydropower generation.

Figure 1 shows the location of Rainbow Dam as it is represented in the HEC-ResSim model. Figure 2 shows the photo of Rainbow Dam.

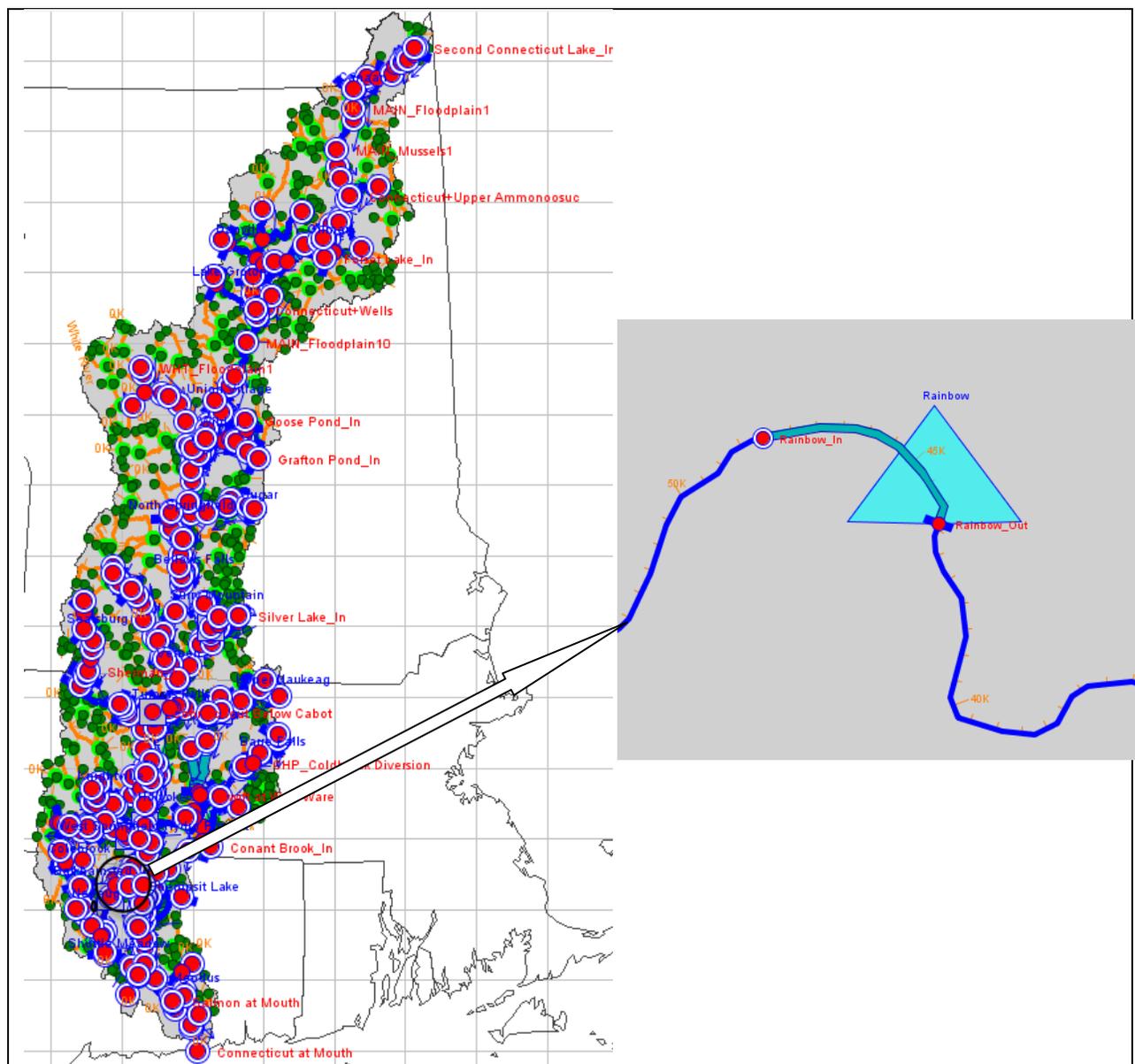


Figure 1: HEC-ResSim Map Display Showing Location of Rainbow



Figure 2: Photo of Rainbow Dam

## II. Physical Characteristics

The physical characteristics of the reservoir are separated between the Pool and the Dam in the HEC-ResSim model. The elevation-storage-area defines the pool as shown in Figure 3<sup>80</sup>. The dam consists of three types of outlets: (1) controlled sluice gates, (2) controlled spillway, and (3) power plant as shown in Figure 4.

---

<sup>80</sup> Data provided by UMASS





## B. Rule Illustrations

Figure 6 shows a set of operational rules specified for each zone that reflects the operation set named Existing Ops.

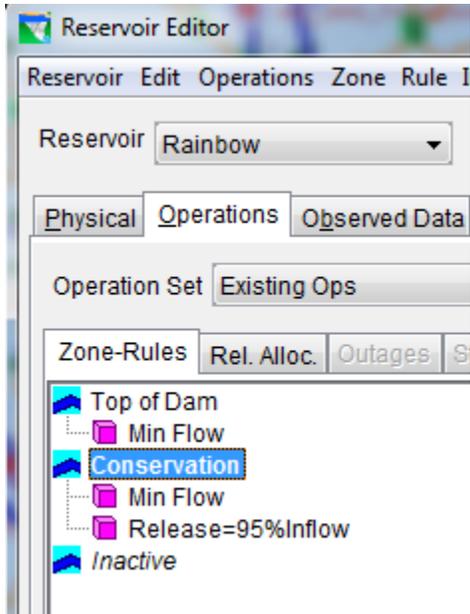


Figure 6: Reservoir Editor: Operations Tab – Existing Ops OpSet – Zones and Rules





# Red Bridge

## I. Overview

Red Bridge dam is located in the towns of Wilbraham and Ludlow, MA on the Chicopee River. It is owned and operated by Essential Power LLC and is operated as run-of-river hydropower generating facility.

Figure 1 shows the location of Red Bridge dam as it is represented in the HEC-ResSim model. Figure 2 shows a photo of Red Bridge dam.

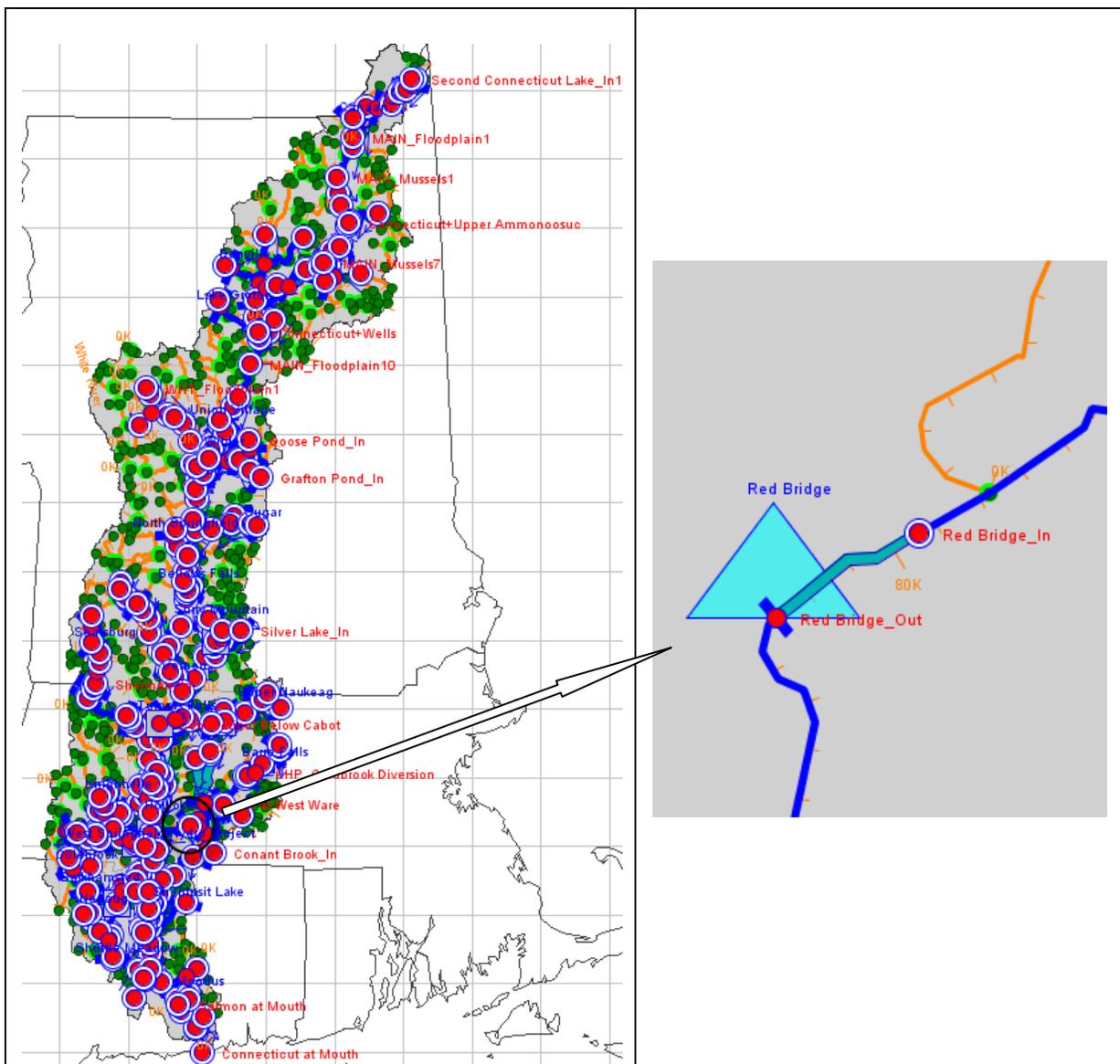


Figure 1: HEC-ResSim Map Display Showing Location of Red Bridge Dam



**Figure 2: Photo of Red Bridge dam**

## **II. Physical Characteristics**

The physical characteristics of the reservoir are separated between the Pool and the Dam in the HEC-ResSim model. The elevation-storage-area defines the pool as shown in Figure 3<sup>81</sup>. The dam consists of two types of outlets: (1) uncontrolled outlet and (3) power plant as shown in Figure 4<sup>1,82</sup>. The capacity of the power plant was made to be the maximum release specified in the NID database so that the dam would modeled completely as run-of-river with some actual physical information

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<sup>81</sup> National Inventory of Dams database (NID)

<sup>82</sup> <http://www.lowimpacthydro.org/lihi-certificate-96-red-bridge-project-ma.html>





## Searsburg

### I. Overview

Searsburg dam is located on the Deerfield River upstream of Harriman. It is owned and operated by TransCanada Hydro Northeast Inc. for hydropower generation on a peaking, seasonal storage basis.

Figure 1 shows the location of Searsburg Dam as it is represented in the HEC-ResSim model. Figure 2 shows a photo from Searsburg Dam.

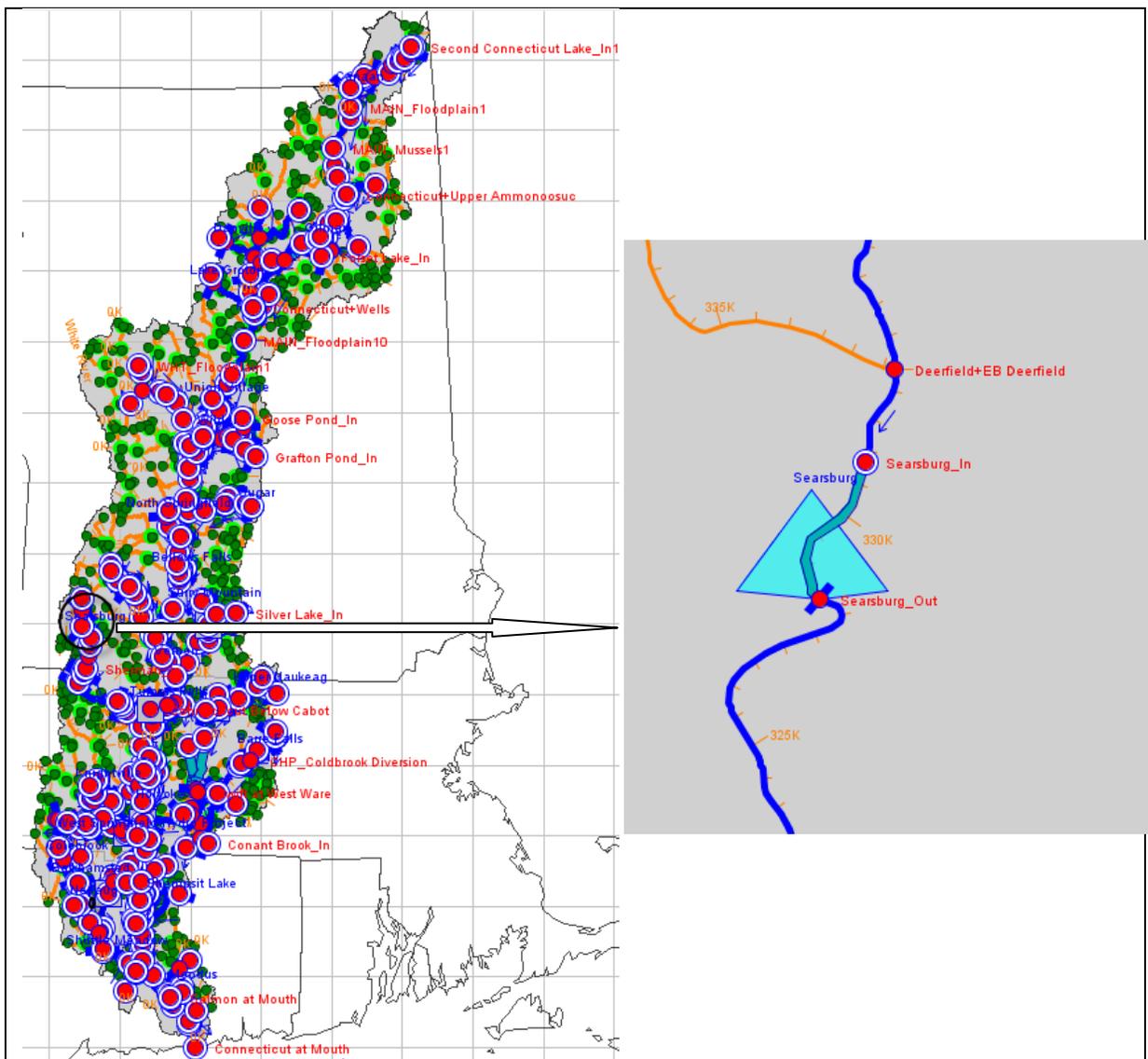


Figure 1: HEC-ResSim Map Display Showing Location of Searsburg dam



Figure 2: Photo of Searsburg Dam

## II. Physical Characteristics

The physical characteristics of the reservoir are separated between the Pool and the Dam in the HEC-ResSim model. The elevation-storage-area defines the pool as shown in Figure 3<sup>83</sup>. The dam consists of five types of outlets: (1) controlled sluice, (2) controlled waste gate, (3) uncontrolled spillway over 5ft flashboards, (4) spillway over clear crest, and (5) power plant as shown in Figure 4.

.

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<sup>83</sup> Data provided by TransCanada

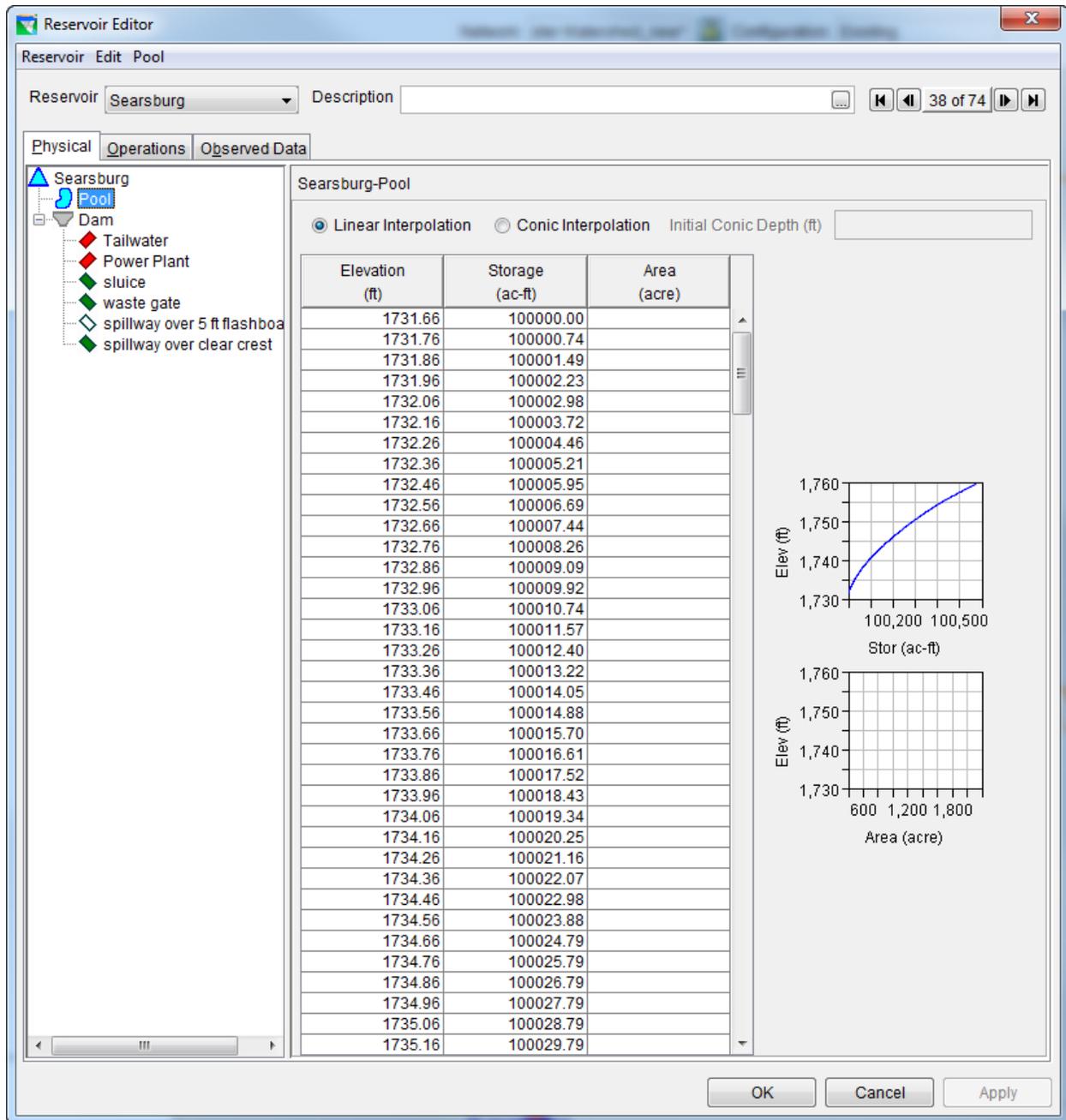


Figure 3: Reservoir Editor: Physical Tab -- Pool

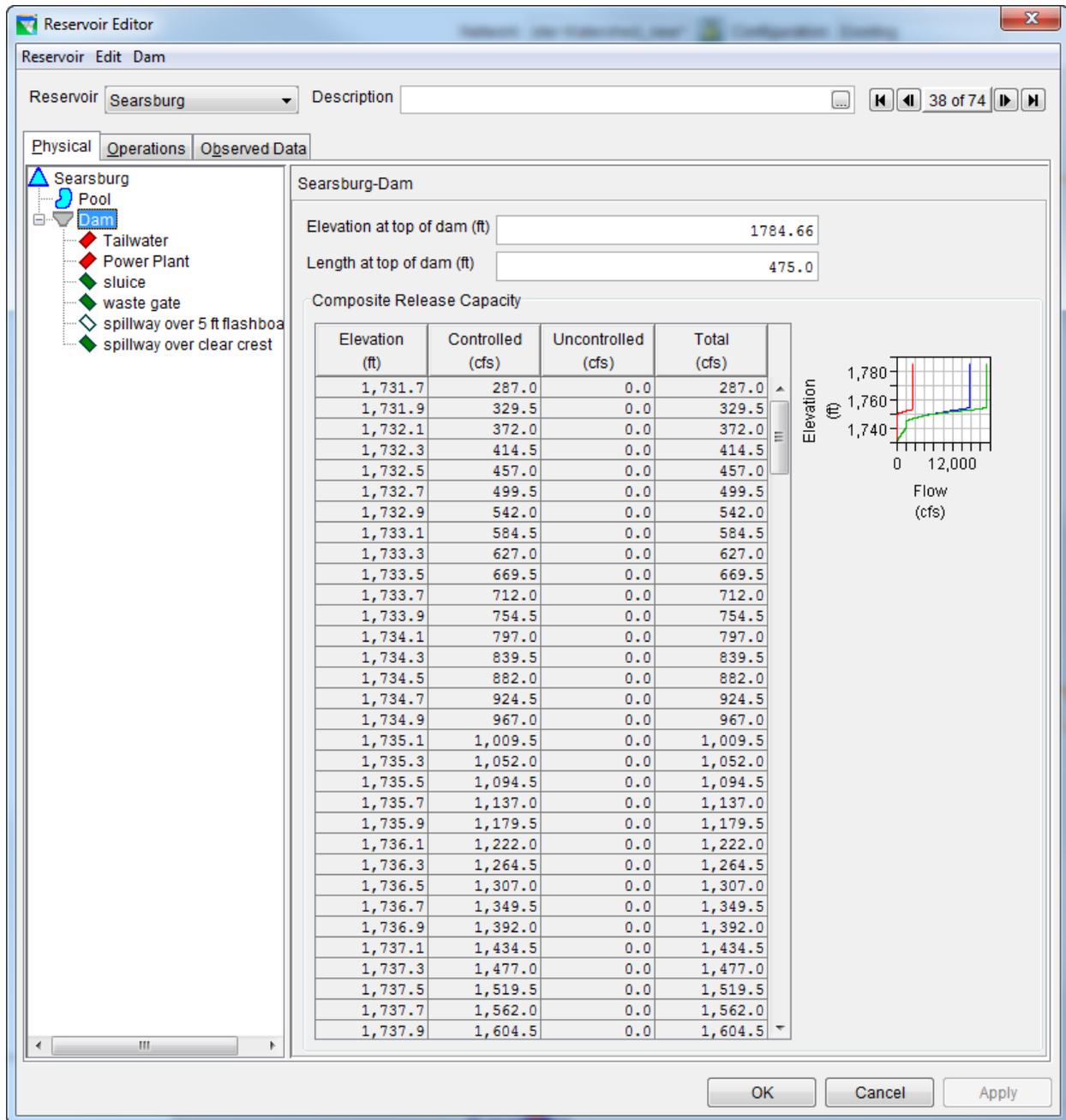


Figure 4: Reservoir Editor: Physical Tab -- Dam



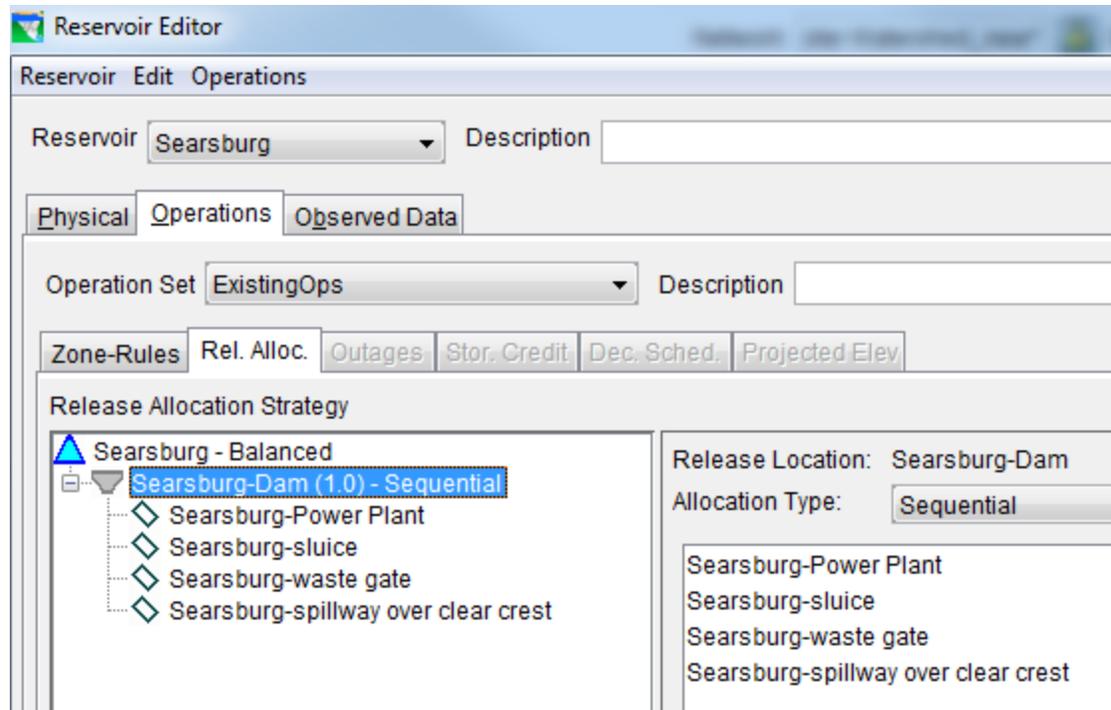


Figure 6: Reservoir Editor: Operations Tab – Existing Ops OpSet – Release Allocation

## B. Rule Illustrations

Figure 7 shows a set of operational rules specified for each zone that reflects the operation set named Existing Ops (TransCanada Corporation).

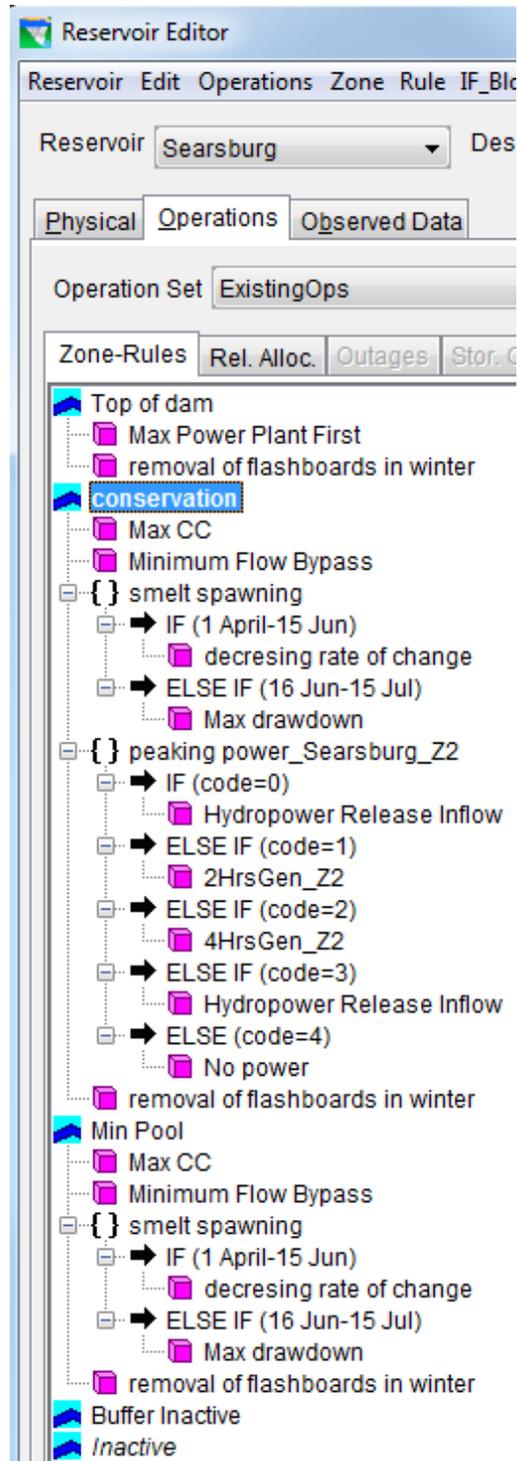


Figure 7: Reservoir Editor: Operations Tab – Existing Ops OpSet – Zones and Rules

## C. Rule Descriptions

### 1. Max Power Plant First

Figure 8 shows the content of “Max Power Plant First” rule. This rule forces the inflow to pass through the power plant first until it reaches the maximum plant capacity.

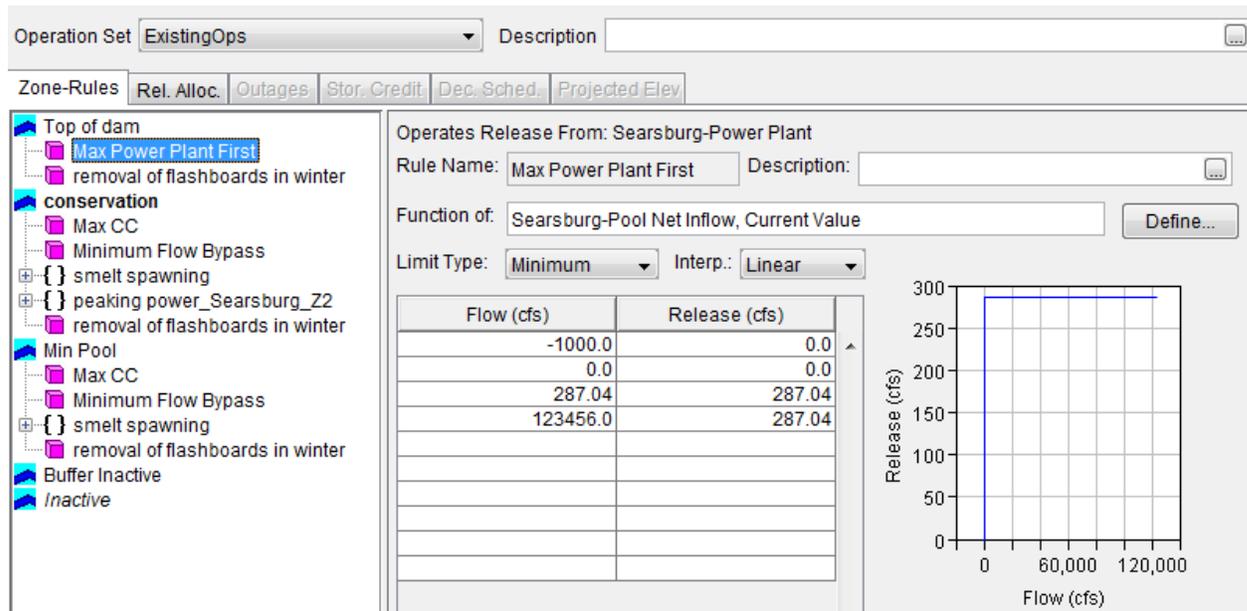


Figure 8: Reservoir Editor: Operations Tab – Existing Ops OpSet – Max Power Plant First

## 2. Removal of flashboards in winter

Figure 9 shows the content of “removal of flashboards in winter” rule. This rule represents the releases through spillways when the flashboards are removed in winters.

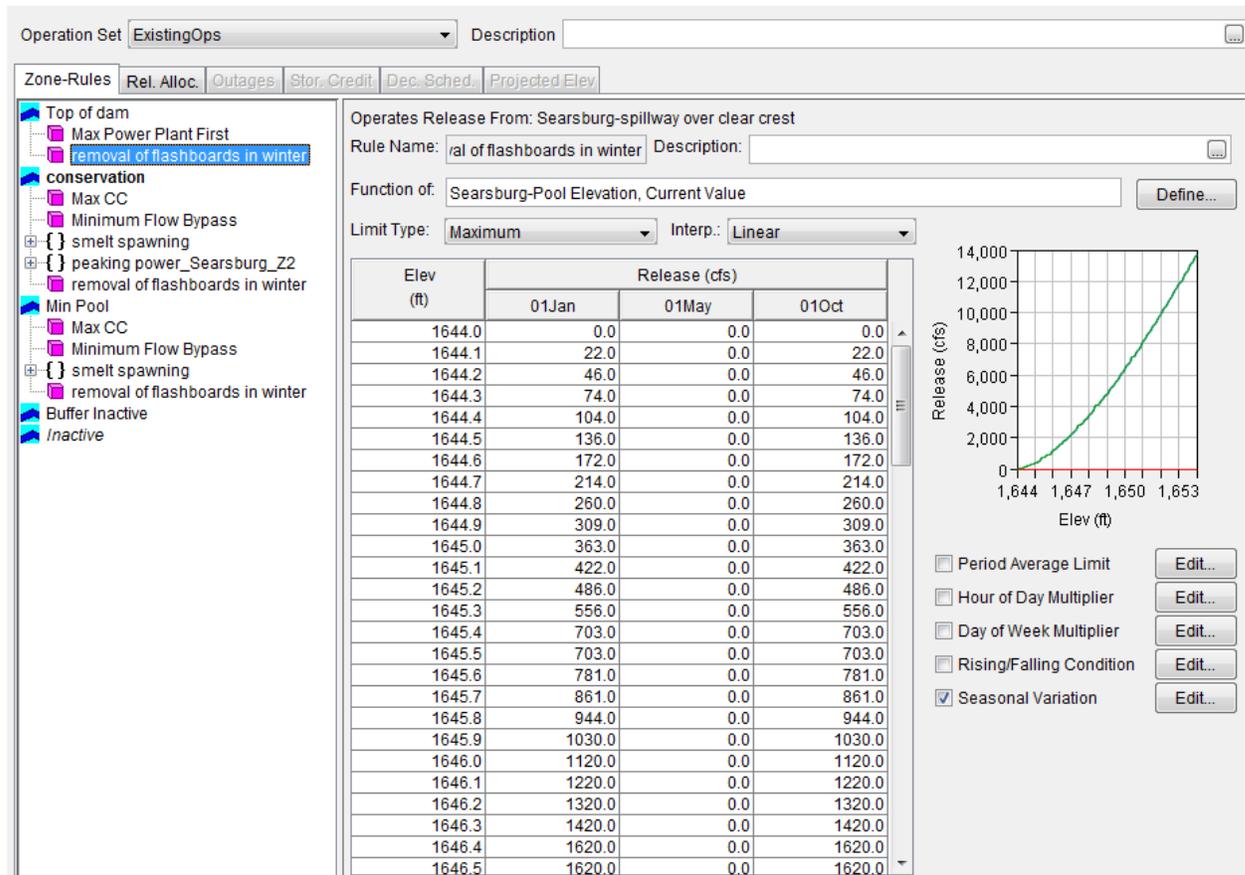


Figure 9 Reservoir Editor: Operations Tab – Existing Ops OpSet – removal of flashboards in winter



### 5. Smelt Spawning

Figure 12 describes the content of “smelt spawning” rule. Based on this rule during Apr1-Jun 15 maximum rate of elevation change is zero, and during Jun 16-Jul 15 the maximum rate of change is one ft/hr.

The figure consists of four screenshots showing the configuration of the "smelt spawning" rule in a software interface. Each screenshot shows the "Operation Set" as "ExistingOps" and the "Operates Release From" as "Searsburg".

**Screenshot 1:** Shows the rule configuration with the name "smelt spawning" and a description. A table lists the rule's conditions:

Type	Name	Description
IF	1 April-15 Jun	
ELSE IF	16 Jun-15 Jul	

**Screenshot 2:** Shows the "IF Conditional" set to "1 April-15 Jun". A table defines the conditions for this period:

	Value1		Value2
	Current Time Step	>=	01Apr
AND	Current Time Step	<=	15Jun

**Screenshot 3:** Shows the "Elevation Rate of Change Limit" set to "decreasing rate of change". The "Function Of" is "Constant" and the "Type" is "Decreasing". The "Max Rate of Change (ft/hr)" is set to 0.0.

**Screenshot 4:** Shows the "ELSE IF Conditional" set to "16 Jun-15 Jul". A table defines the conditions for this period:

	Value1		Value2
	Current Time Step	>=	16Jun
AND	Current Time Step	<=	15Jul

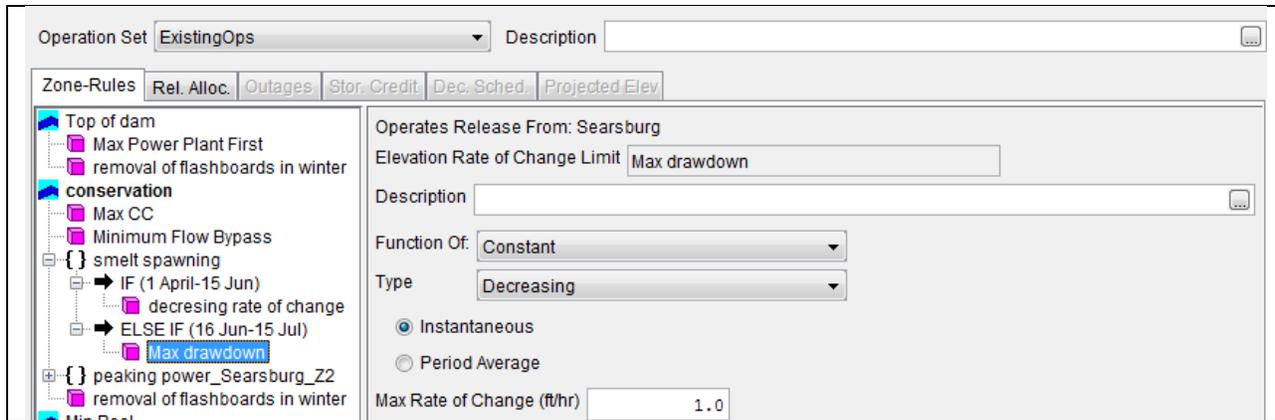
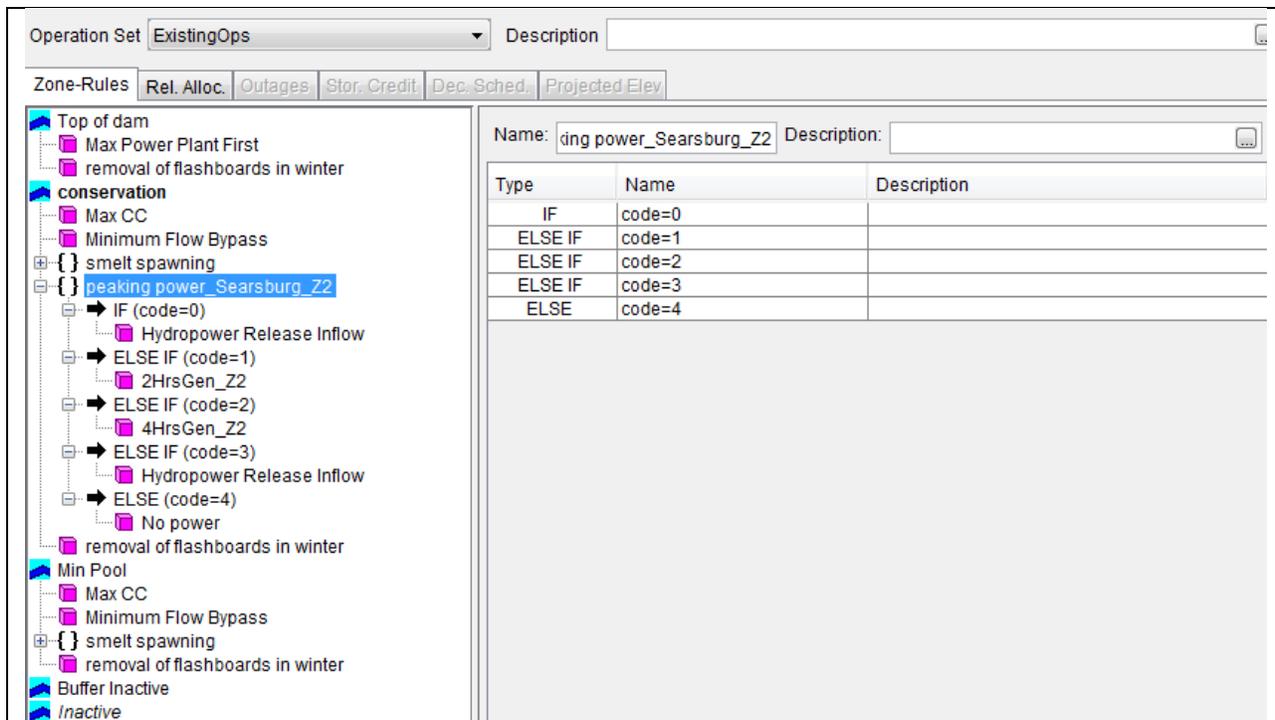


Figure 12: Reservoir Editor: Operations Tab – Existing Ops OpSet – Smelt Spawning

### 6. Peaking power\_Searsburg\_Z2

This rule represents power strategy applied for Searsburg reservoir. The content of the rule is shown in Figure 11 as per the peaking hydropower modeling strategy.



Operation Set: ExistingOps Description:

Zone-Rules: Rel. Alloc. Outages Stor. Credit Dec. Sched. Projected Elev.

- Top of dam
  - Max Power Plant First
  - removal of flashboards in winter
- conservation
  - Max CC
  - Minimum Flow Bypass
  - smelt spawning
  - peaking power\_Searsburg\_Z2
    - IF (code=0)
      - Hydropower Release Inflow
      - ELSE IF (code=1)
      - 2HrsGen\_Z2
      - ELSE IF (code=2)
      - 4HrsGen\_Z2
      - ELSE IF (code=3)
      - Hydropower Release Inflow
      - ELSE (code=4)
      - No power

IF Conditional: code=0 Description:

Value1	Value2
Searsburg_Volume	= 0

---

- Top of dam
  - Max Power Plant First
  - removal of flashboards in winter
- conservation
  - Max CC
  - Minimum Flow Bypass
  - smelt spawning
  - peaking power\_Searsburg\_Z2
    - IF (code=0)
      - Hydropower Release Inflow
      - ELSE IF (code=1)
      - 2HrsGen\_Z2
      - ELSE IF (code=2)
      - 4HrsGen\_Z2
      - ELSE IF (code=3)
      - Hydropower Release Inflow
      - ELSE (code=4)
      - No power

Operates Release From: Searsburg-Power Plant

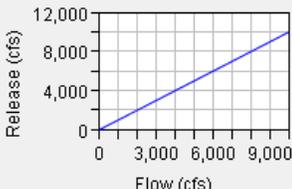
Rule Name: ydropower Release Inflow Description:

Function of: Searsburg-Pool Net Inflow, Current Value

Limit Type: Minimum Interp.: Linear

Flow (cfs)	Release (cfs)
0.0	0.0
10000.0	10000.0

Period Average Limit   
 Hour of Day Multiplier



---

- Top of dam
  - Max Power Plant First
  - removal of flashboards in winter
- conservation
  - Max CC
  - Minimum Flow Bypass
  - smelt spawning
  - peaking power\_Searsburg\_Z2
    - IF (code=0)
      - Hydropower Release Inflow
      - ELSE IF (code=1)
        - 2HrsGen\_Z2
        - ELSE IF (code=2)
        - 4HrsGen\_Z2
        - ELSE IF (code=3)
        - Hydropower Release Inflow
        - ELSE (code=4)
        - No power

Operates Release From: Searsburg-Power Plant

ELSE IF Conditional: code=1 Description:

Value1	Value2
Searsburg_Volume	= 1

Operation Set: ExistingOps | Description: \_\_\_\_\_

Zone-Rules | Rel. Alloc. | Outages | Stor. Credit | Dec. Sched. | Projected Elev.

Top of dam

- Max Power Plant First
- removal of flashboards in winter
- conservation
  - Max CC
  - Minimum Flow Bypass
  - smelt spawning
  - peaking power\_Searsburg\_Z2
    - IF (code=0)
      - Hydropower Release Inflow
      - ELSE IF (code=1)
        - 2HrsGen\_Z2
      - ELSE IF (code=2)
        - 4HrsGen\_Z2
      - ELSE IF (code=3)
        - Hydropower Release Inflow
      - ELSE (code=4)
        - No power
    - removal of flashboards in winter
  - Min Pool
    - Max CC

Operates Release From: Searsburg-Power Plant

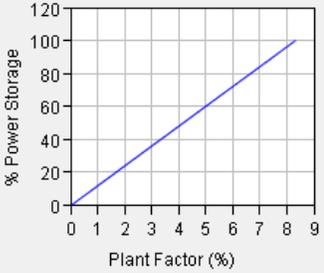
Hydropower - Power Guide Curve Rule: 2HrsGen\_Z2

Description: \_\_\_\_\_

Zone at Top of Power Pool: conservation

Zone at Bottom of Power Pool: Min Pool

% Power Storage	Plant Factor (%)
0.0	0.0
100.0	8.33



---

Top of dam

- Max Power Plant First
- removal of flashboards in winter
- conservation
  - Max CC
  - Minimum Flow Bypass
  - smelt spawning
  - peaking power\_Searsburg\_Z2
    - IF (code=0)
      - Hydropower Release Inflow
      - ELSE IF (code=1)
        - 2HrsGen\_Z2
      - ELSE IF (code=2)
        - 4HrsGen\_Z2
      - ELSE IF (code=3)
        - Hydropower Release Inflow
      - ELSE (code=4)
        - No power
    - removal of flashboards in winter
  - Min Pool
    - Max CC

Operates Release From: Searsburg-Power Plant

ELSE IF Conditional: code=2 | Description: \_\_\_\_\_

Value1	Value2
Searsburg_Volume	= 2

Add Cond.

Del. Cond.

Move Up

Move Down

Evaluate

---

Top of dam

- Max Power Plant First
- removal of flashboards in winter
- conservation
  - Max CC
  - Minimum Flow Bypass
  - smelt spawning
  - peaking power\_Searsburg\_Z2
    - IF (code=0)
      - Hydropower Release Inflow
      - ELSE IF (code=1)
        - 2HrsGen\_Z2
      - ELSE IF (code=2)
        - 4HrsGen\_Z2
      - ELSE IF (code=3)
        - Hydropower Release Inflow
      - ELSE (code=4)
        - No power
    - removal of flashboards in winter
  - Min Pool
    - Max CC

Operates Release From: Searsburg-Power Plant

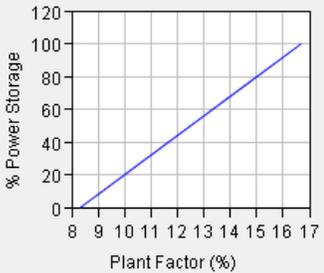
Hydropower - Power Guide Curve Rule: 4HrsGen\_Z2

Description: \_\_\_\_\_

Zone at Top of Power Pool: conservation

Zone at Bottom of Power Pool: Min Pool

% Power Storage	Plant Factor (%)
0.0	8.33
100.0	16.67



Operation Set: ExistingOps Description:

Zone-Rules: Rel. Alloc. Outages Stor. Credit Dec. Sched. Projected Elev.

- Top of dam
  - Max Power Plant First
  - removal of flashboards in winter
- conservation
  - Max CC
  - Minimum Flow Bypass
  - smelt spawning
  - peaking power\_Searsburg\_Z2
    - IF (code=0)
      - Hydropower Release Inflow
    - ELSE IF (code=1)
      - 2HrsGen\_Z2
    - ELSE IF (code=2)
      - 4HrsGen\_Z2
    - ELSE IF (code=3)
      - Hydropower Release Inflow
    - ELSE (code=4)
      - No power
  - removal of flashboards in winter

Operates Release From: Searsburg-Power Plant

ELSE IF Conditional: code=3 Description:

Value1		Value2
Searsburg_Volume	=	3

---

- Top of dam
  - Max Power Plant First
  - removal of flashboards in winter
- conservation
  - Max CC
  - Minimum Flow Bypass
  - smelt spawning
  - peaking power\_Searsburg\_Z2
    - IF (code=0)
      - Hydropower Release Inflow
    - ELSE IF (code=1)
      - 2HrsGen\_Z2
    - ELSE IF (code=2)
      - 4HrsGen\_Z2
    - ELSE IF (code=3)
      - Hydropower Release Inflow
    - ELSE (code=4)
      - No power

Operates Release From: Searsburg-Power Plant

Rule Name: hydropower Release Inflow Description:

Function of: Searsburg-Pool Net Inflow, Current Value

Limit Type: Minimum Interp.: Linear

Flow (cfs)	Release (cfs)
0.0	0.0
10000.0	10000.0

Release (cfs)

Flow (cfs)

Period Average Limit

Hour of Day Multiplier

---

- Top of dam
  - Max Power Plant First
  - removal of flashboards in winter
- conservation
  - Max CC
  - Minimum Flow Bypass
  - smelt spawning
  - peaking power\_Searsburg\_Z2
    - IF (code=0)
      - Hydropower Release Inflow
    - ELSE IF (code=1)
      - 2HrsGen\_Z2
    - ELSE IF (code=2)
      - 4HrsGen\_Z2
    - ELSE IF (code=3)
      - Hydropower Release Inflow
    - ELSE (code=4)
      - No power

Operates Release From: Searsburg-Power Plant

ELSE Conditional: code=4 Description:



State Variable Editor

Name:  Description:

Parameter Name:  Parameter Type:   Always Compu

Initialization Main CleanUp

```

1 # Create a code to track the available water for generating power
2
3 #The code is summing up the current Inflow and previous storage in each timestep, compare it to the volume needed for
4 #generating 2 and 4 hours power and to the spillway storage minus inactive storage and then decide how much to release.
5
6 # Code =0: I+S >S (spillway storage)-S (inactive storage)
7 # code =1:0< I+S<V(2hrs.Gen)
8 # code =2: V(2hrs.Gen)<I+S<V(4hrs.Gen)
9 # code =3: V(4hrs.Gen)<I+S
10
11 # S (spillway storage)-S (inactive storage)=600-372.96=227.04 (acf)
12 #outlet capacity=587.4 (cfs)
13 #V(2hrs.Gen)=(2*outlet capacity)*0.082=96 (acf)
14 #V(4hrs.Gen)=(4*outlet capacity)*0.082=192 (acf)
15
16 from hec.model import RunTimeStep
17
18 Inflow_TS=network.getTimeSeries("Reservoir","Searsburg", "Pool", "Flow-IN NET")
19 Inflow= Inflow_TS.getCurrentValue(currentRunTimeStep)
20 Inflow_acf=Inflow*1.98
21
22 Storage_TS = network.getTimeSeries("Reservoir","Searsburg", "Pool", "Stor")
23 Storage=Storage_TS.getPreviousValue(currentRunTimeStep)-100000
24
25 Volume=Inflow_acf+(Storage-372.96)
26
27 if Volume >= 227.04:
28     Code=0
29 elif 0<Volume <=96 :
30     Code=1
31 elif 96<Volume <=192:
32     Code=2
33 elif 192<Volume<227.04:
34     Code=3
35 else:
36     Code=4
37
38 currentVariable.setValue(currentRunTimeStep,Code)

```

Figure 14: State Variable Editor: Searsburg\_Volume

## Second Connecticut Lake

### I. Overview

Second Connecticut Lake dam is located 8 miles south of the Canadian border on the mainstem Connecticut River. It is owned and operated by TransCanada Hydro Northeast Inc. as a storage reservoir to make releases to its downstream hydro facilities.

Figure 1 shows the location of Second Connecticut Dam as it is represented in the HEC-ResSim model, and Figure 2 shows a photo from Second Connecticut Dam.

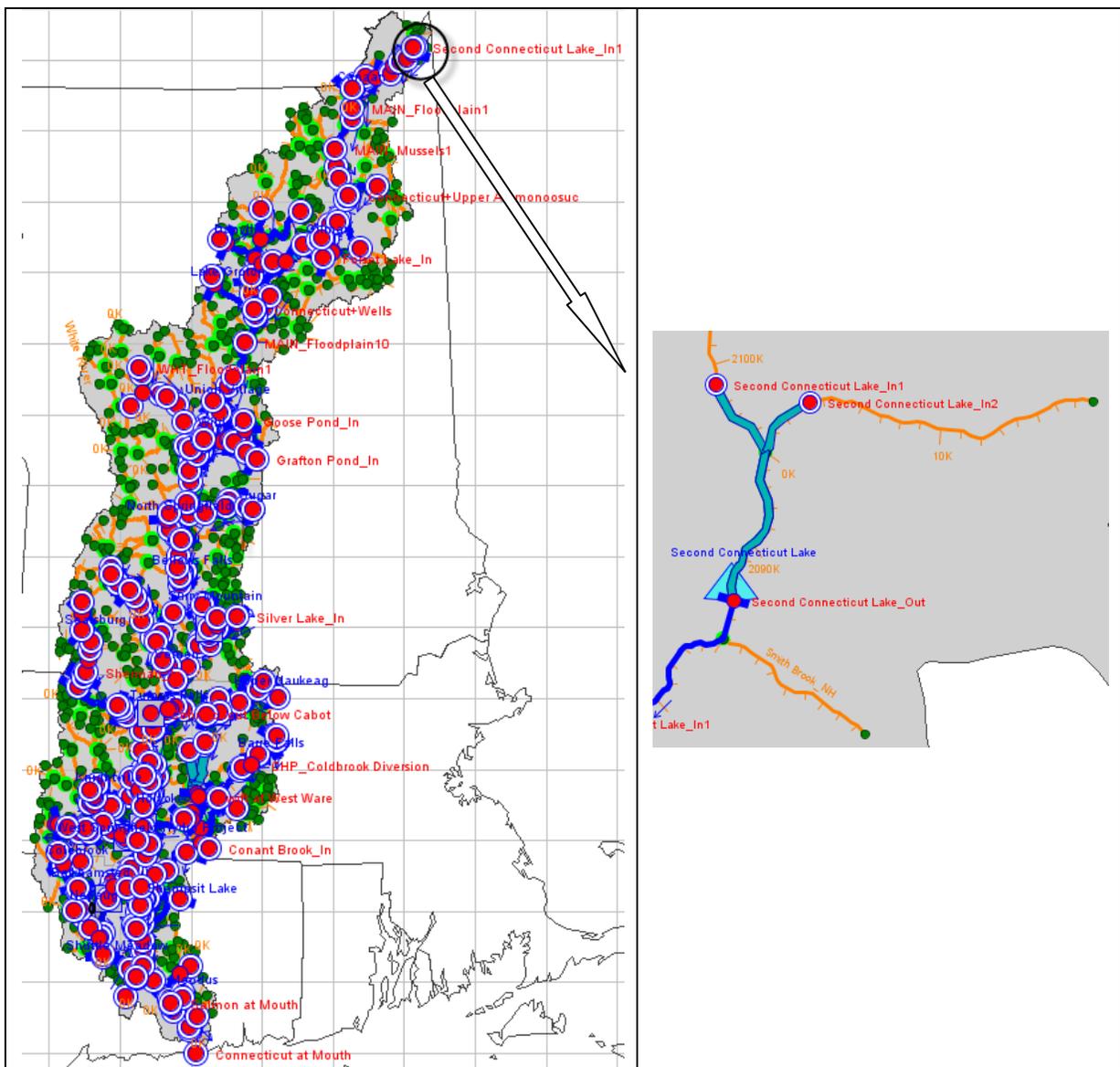


Figure 1: HEC-ResSim Map Display Showing Location of Second Connecticut Dam



**Figure 2: Photo of Second Connecticut Dam**

## **II. Physical Characteristics**

The physical characteristics of the reservoir are separated between the Pool and the Dam in the HEC-ResSim model. The elevation-storage-area defines the pool as shown in Figure 3<sup>84</sup>. The dam consists of four types of outlets: (1) controlled Log way, (2) uncontrolled spillway, (3) controlled Fish Pipe, and (4) controlled Waste way as shown in Figure 4.

---

<sup>84</sup> Data provided by TransCanada

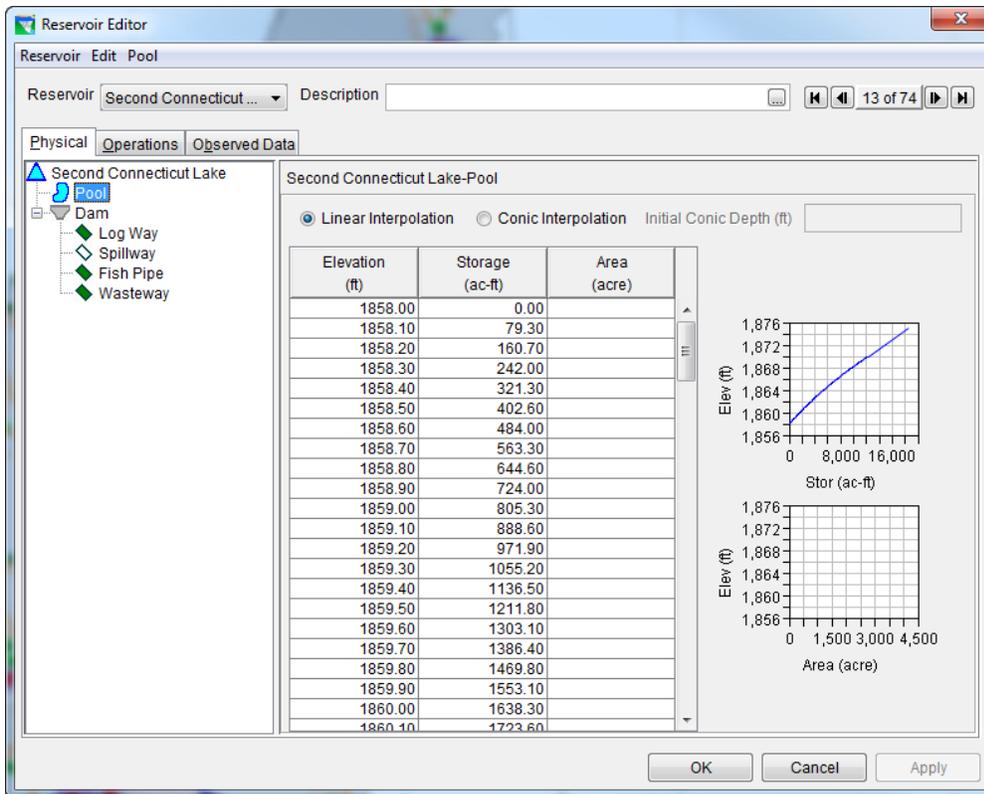


Figure 3: Reservoir Editor: Physical Tab -- Pool

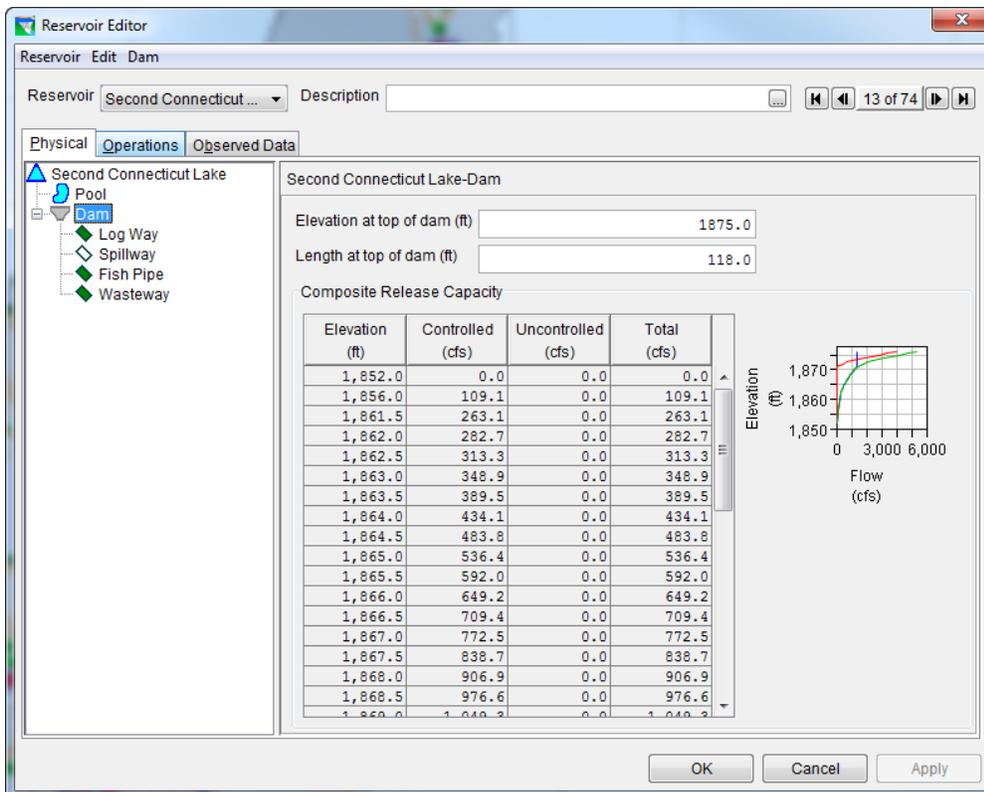


Figure 4: Reservoir Editor: Physical Tab -- Dam

### III. Operations

#### A. Operation Set

Zones are used to define the operational storage in the reservoir to determine the reservoir release through analysis of the rules contained within each zone. Figure 5 shows the definition of Second Connecticut Dam’s “Existing Ops” operational zones, which consist of zones of Top of dam (1875 ft), Below Top of dam (1874 ft), Conservation (1861.248-1867.215 ft), Operational Inactive (1860 ft), and Inactive zone (1859 ft). The Conservation Pool Elevation curve was created from 10 years of weekly average pool elevation<sup>1</sup>.

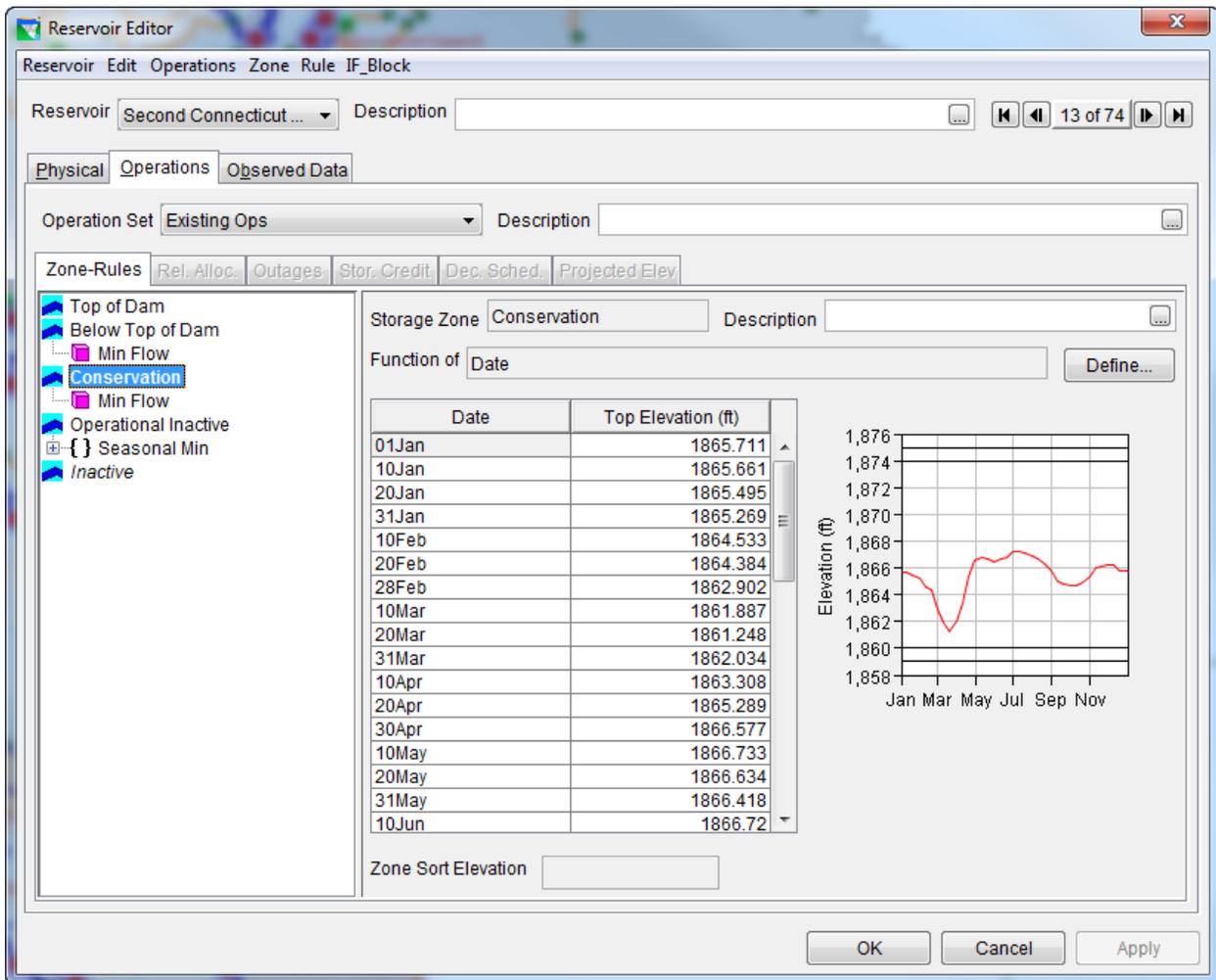


Figure 5: Reservoir Editor: Operations Tab –Existing Ops OpSet – Guide Curve

## B. Rule Illustrations

Figure 6 shows a set of operational rules specified for each zone that reflects the operation set named Existing Ops<sup>85</sup>.

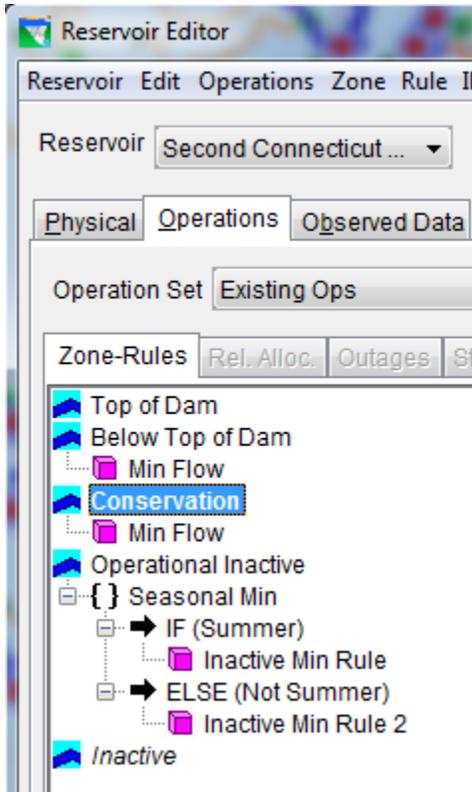


Figure 6: Reservoir Editor: Operations Tab – Existing Ops OpSet – Zones and Rules

<sup>85</sup> TransCanada. Connecticut River Operational Constraints. 2012.

## C. Rule Descriptions

### 1. Min Flow

Figure 7 shows the content of “Min Flow” rule. This rule represents the minimum release from dam as a function of date.

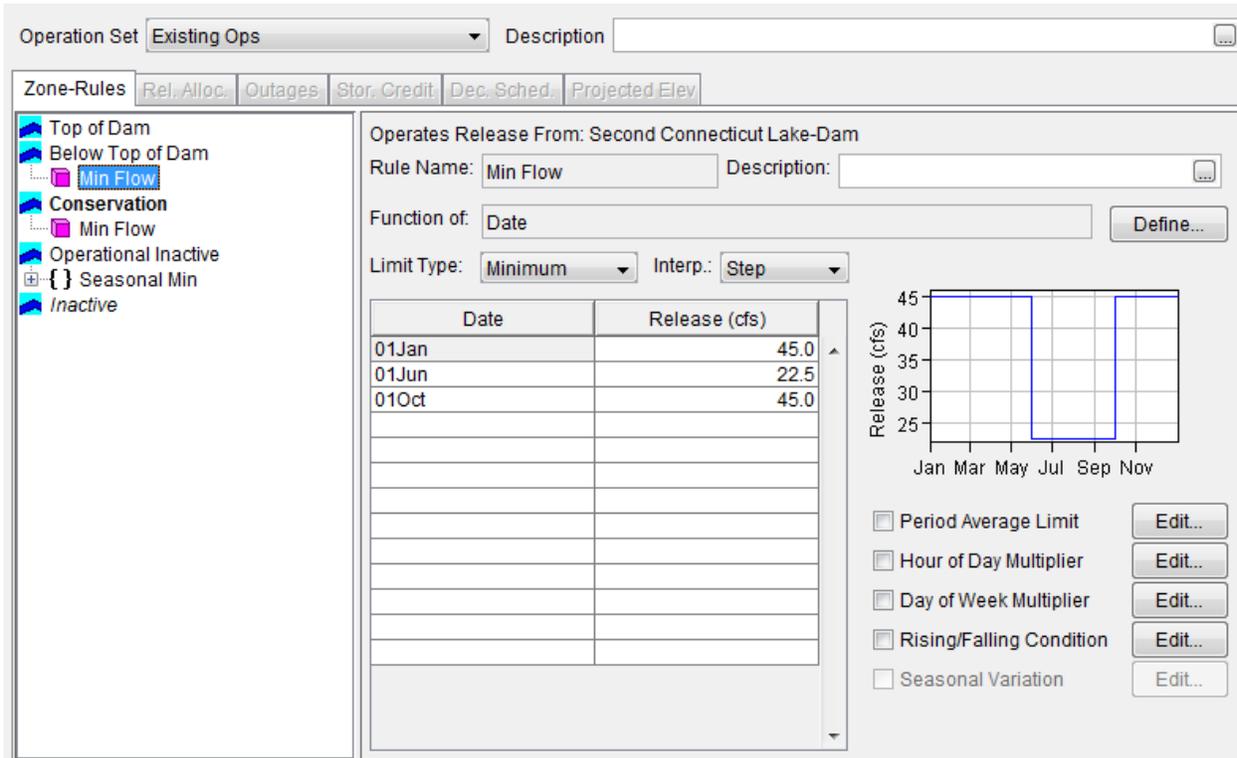


Figure 7: Reservoir Editor: Operations Tab – Existing Ops OpSet – Min Flow

## 2. Seasonal Min

Figure 8 shows the content of “Seasonal Min” rule. It represents a minimum release of 22.5 cfs for inflows greater than 22.5 cfs in summer and 45 cfs for inflows greater than 45 cfs in the rest of the year.

The figure consists of three screenshots from a software interface, likely for dam operations, showing the configuration of a rule named "Seasonal Min".

**Top Screenshot:** Shows the "Seasonal Min" rule selected in a tree view. The right pane shows the rule details: Name: Seasonal Min, Description: (empty). A table below shows the conditional logic:

Type	Name	Description
IF	Summer	
ELSE	Not Summer	

**Middle Screenshot:** Shows the "IF (Summer)" rule selected. The right pane shows the conditional logic for the "IF (Summer)" rule. The "IF Conditional" is "Summer". A table below shows the conditional logic:

Value1	Operator	Value2
Current Time Step	>=	01Jun
Current Time Step	<=	30Sep

**Bottom Screenshot:** Shows the "Inactive Min Rule" selected. The right pane shows the rule details: Operates Release From: Second Connecticut Lake, Rule Name: Inactive Min Rule, Description: (empty). The function is "Second Connecticut Lake-Pool Net Inflow, Current Value". The limit type is "Minimum" and the interpolation is "Linear". A table below shows the release function:

Flow (cfs)	Release (cfs)
0.0	0.0
22.5	22.5
100000.0	22.5

To the right of the table is a graph showing Release (cfs) on the y-axis (0 to 20) and Flow (cfs) on the x-axis (0 to 80,000). The graph shows a horizontal line at 22.5 cfs release for flow values greater than 22.5 cfs.

Operation Set: Existing Ops Description: [ ]

Zone-Rules: Rel. Alloc. Outages Stor. Credit Dec. Sched. Projected Elev

Operates Release From: Second Connecticut Lake

ELSE Conditional: Not Summer Description: [ ]

---

Operation Set: Existing Ops Description: [ ]

Zone-Rules: Rel. Alloc. Outages Stor. Credit Dec. Sched. Projected Elev

Operates Release From: Second Connecticut Lake

Rule Name: Inactive Min Rule 2 Description: [ ]

Function of: Second Connecticut Lake-Pool Net Inflow, Current Value Define...

Limit Type: Minimum Interp.: Linear

Flow (cfs)	Release (cfs)
0.0	0.0
45.0	45.0
100000.0	45.0

Figure 8: Reservoir Editor: Operations Tab – Existing Ops OpSet – Seasonal Min

# Lake Shenipsit

## I. Overview

Lake Shenipsit Dam is located in the town of Rockville, CT on the Hockanum River. It is owned and operated by the Connecticut Water Company and used as water supply for the town of Rockville.

Figure 1 shows the location of Lake Shenipsit Dam as it is represented in the HEC-ResSim model. Figure 2 shows a photo of Lake Shenipsit.

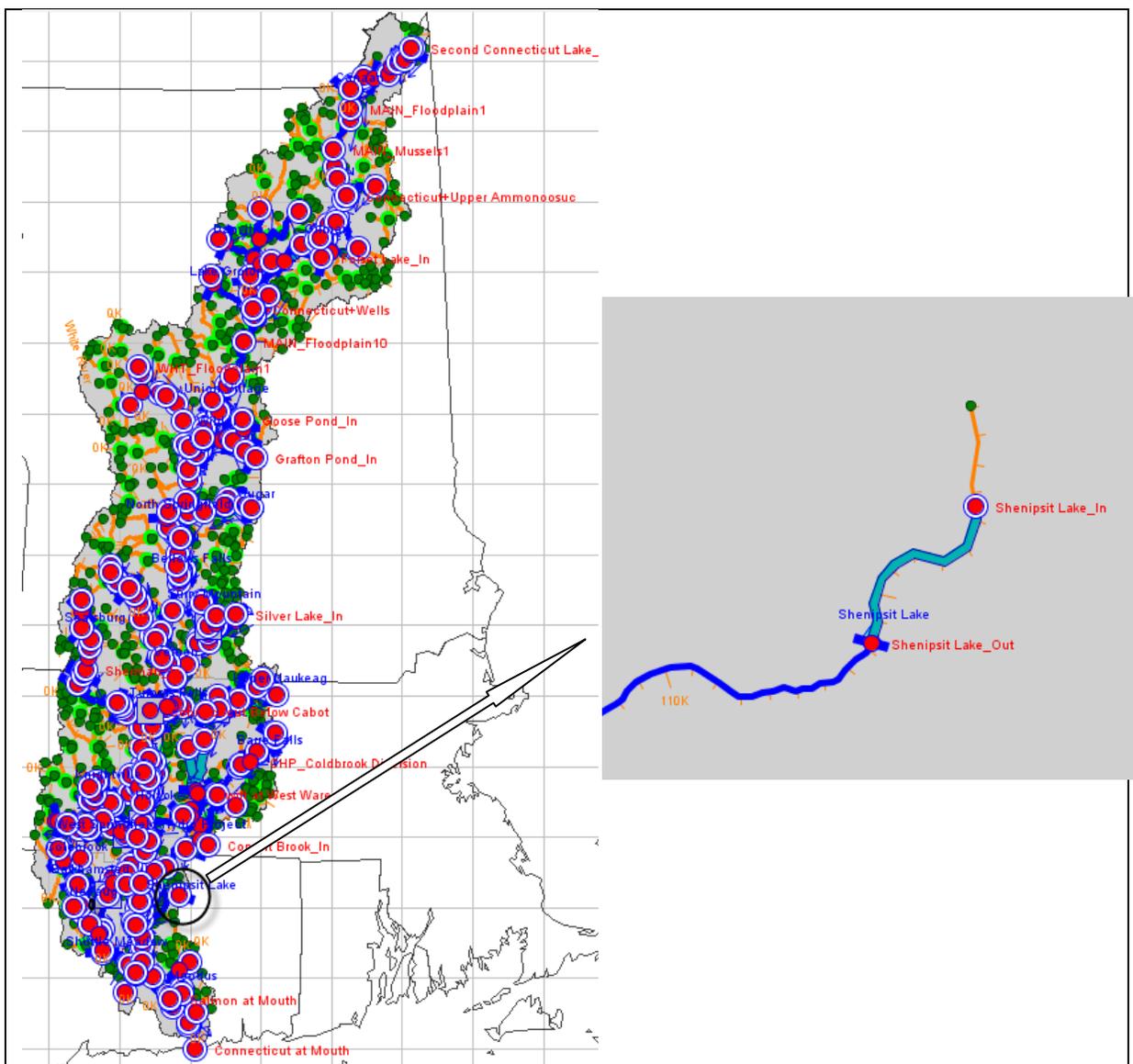


Figure 1: HEC-ResSim Map Display Showing Location of Lake Shenipsit Dam



Figure 2: Photo of Lake Shenipsit

## II. Physical Characteristics

The physical characteristics of the reservoir are separated between the Pool and the Dam in the HEC-ResSim model. The elevation-storage-area defines the pool as shown in Figure 3<sup>86</sup>. The dam consists of two types of outlets: (1) uncontrolled outlet, and (2) controlled water to treatment plant gate as shown in Figure 4.

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<sup>86</sup> Data provided by Connecticut Water Company.

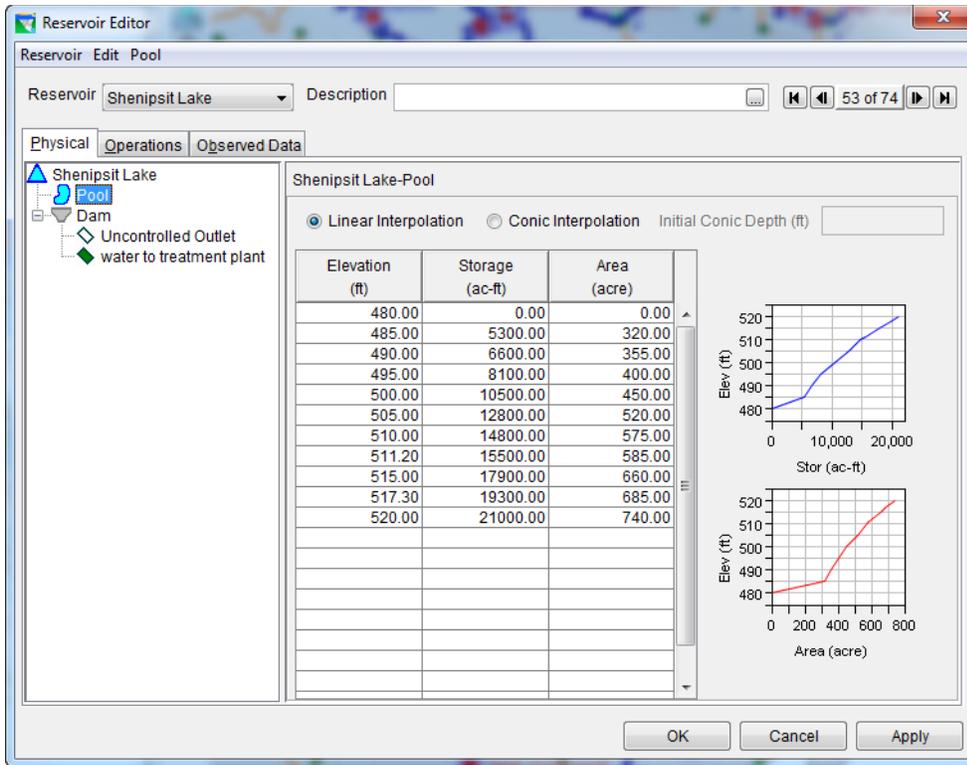


Figure 3: Reservoir Editor: Physical Tab -- Pool

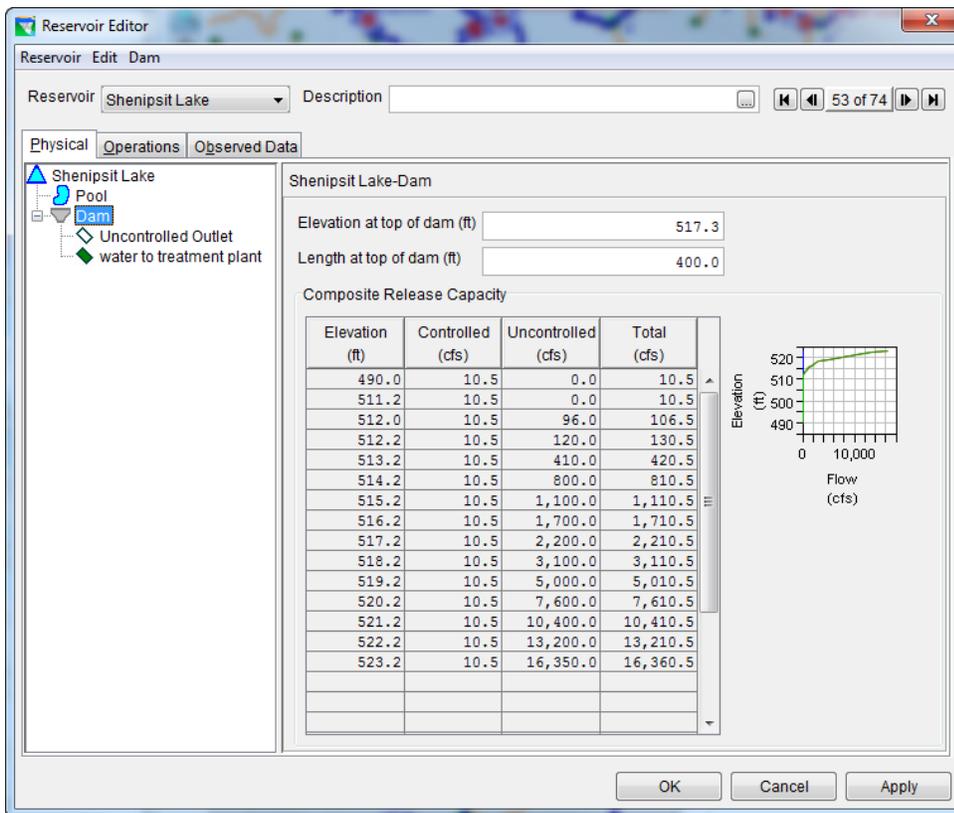


Figure 4: Reservoir Editor: Physical Tab -- Dam

### III. Operations

#### B. Operation Set

Zones are used to define the operational storage in the reservoir to determine the reservoir release through analysis of the rules contained within each zone. Figure 4 shows the definition of Shenipsit’s “Existing Ops” operational zones, which consist of zones of Top of dam (517.3 ft), Flood control (512 ft), Conservation (511 ft), and Inactive zone (490 ft)<sup>1</sup>.

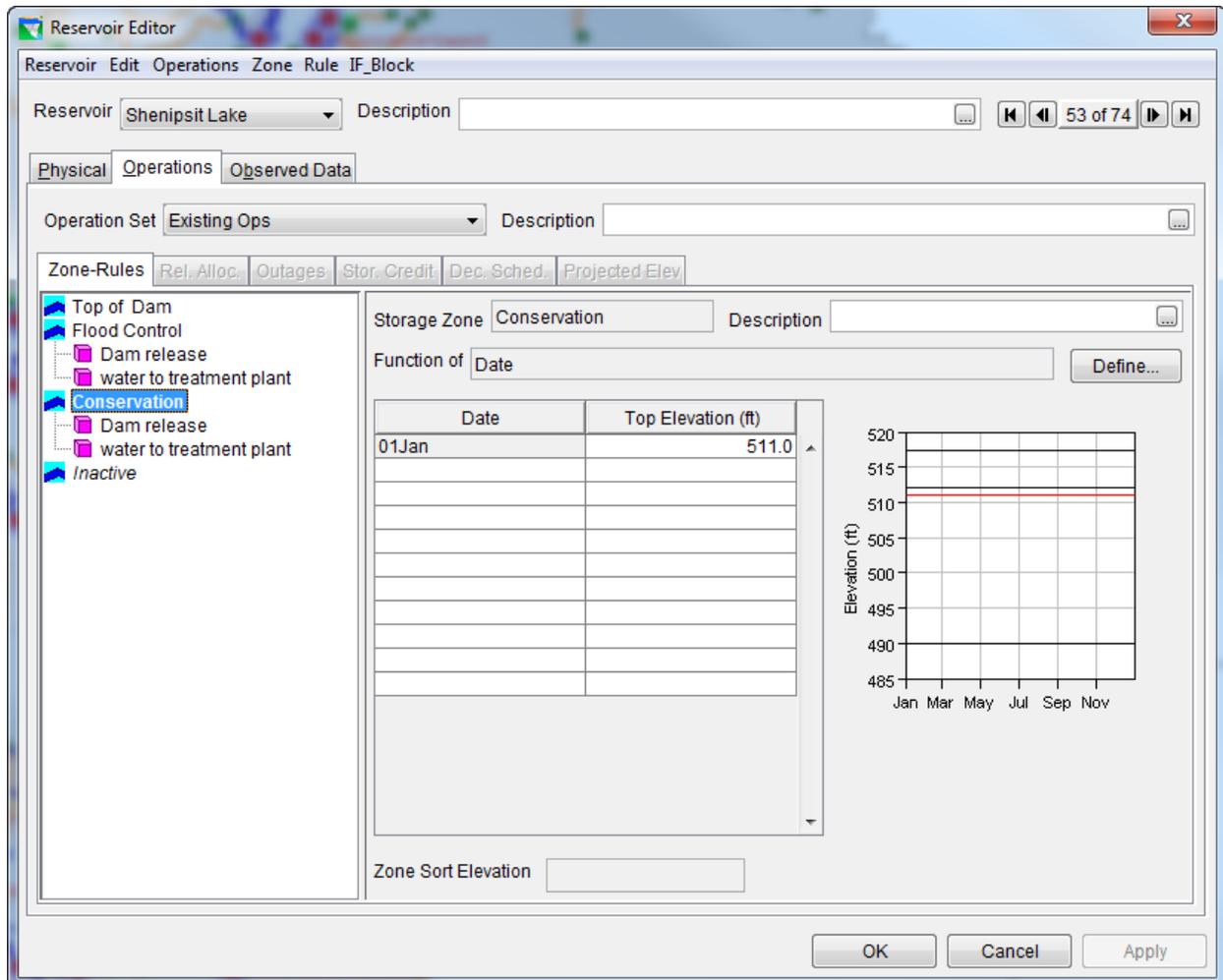


Figure 5: Reservoir Editor: Operations Tab – Existing Ops OpSet

## B. Rule Illustrations

Figure 6 shows a set of operational rules specified for each zone that reflects the operation set named Guide Curve.

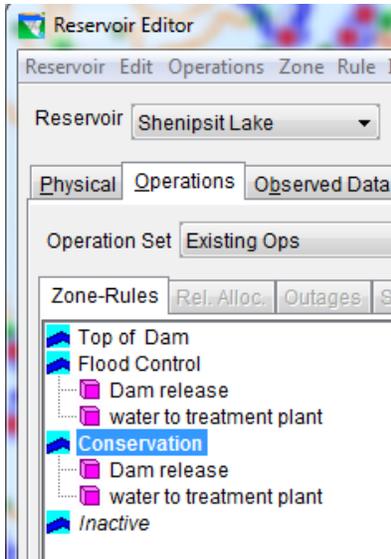


Figure 6: Reservoir Editor: Operations Tab – Existing Ops OpSet – Zones and Rules

## C. Rule Descriptions

### 1. Dam release

Figure 6 shows the content of “Dam release” rule. This rule represents the minimum release from Dam as a function of date.

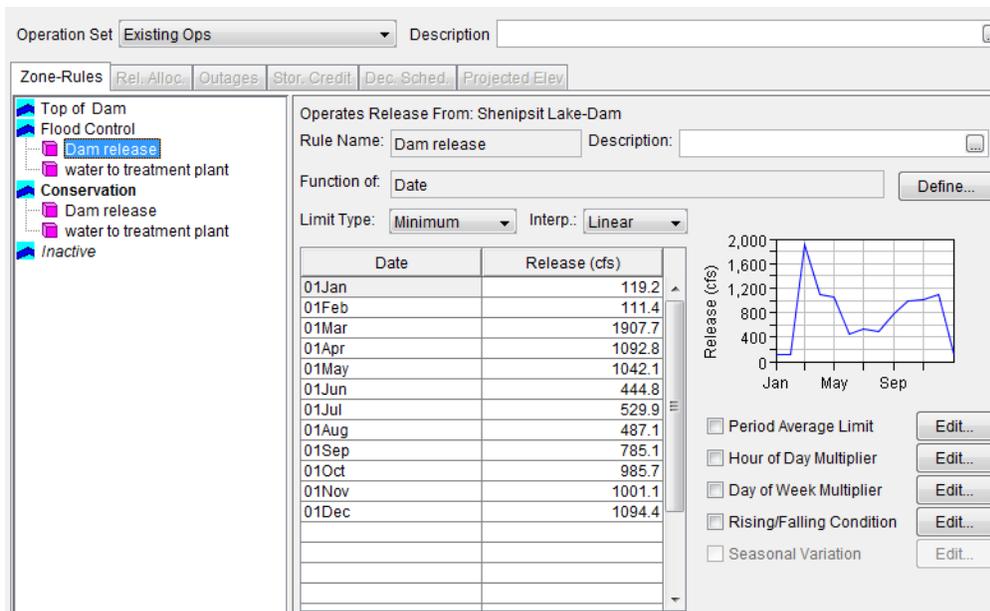


Figure 6 Reservoir Editor: Operations Tab – Existing Ops OpSet – Dam release

## 2. Water to treatment Plant

Figure 7 shows the content of “Water to treatment” rule. This rule represents the minimum release from “water to treatment plant” gate.

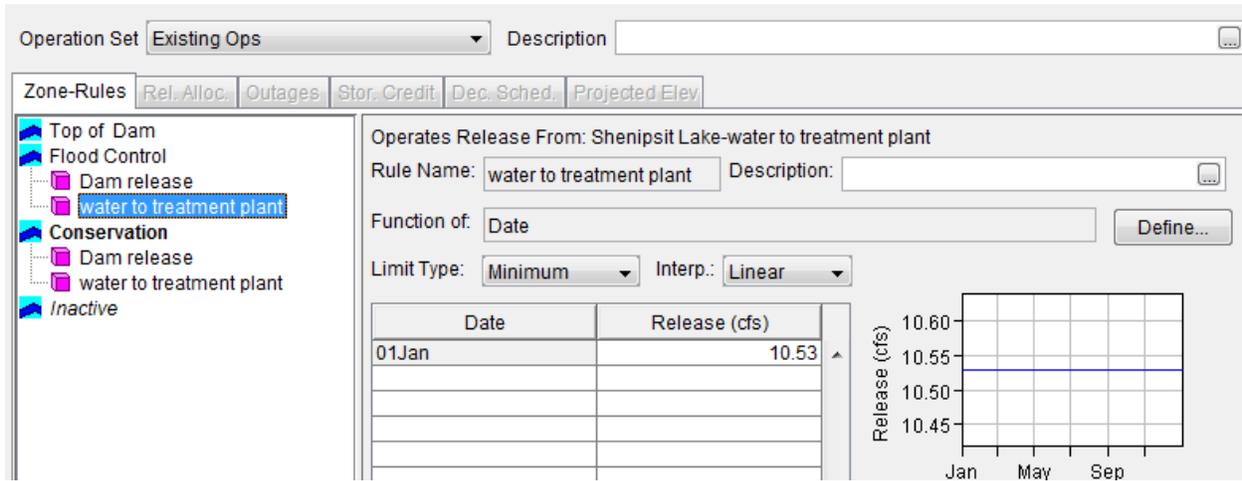


Figure 7: Reservoir Editor: Operations Tab – Existing Ops OpSet – water to treatment plant

# Sherman

## I. Overview

Sherman dam is located on the Deerfield River between Readsboro and Monroe. It is owned and operated by TransCanada Hydro Northeast Inc. for hydropower generation on a peaking, weekly storage basis.

Figure 1 shows the location of Sherman dam as it is represented in the HEC-ResSim model. Figure 2 shows a photo of Sherman dam.

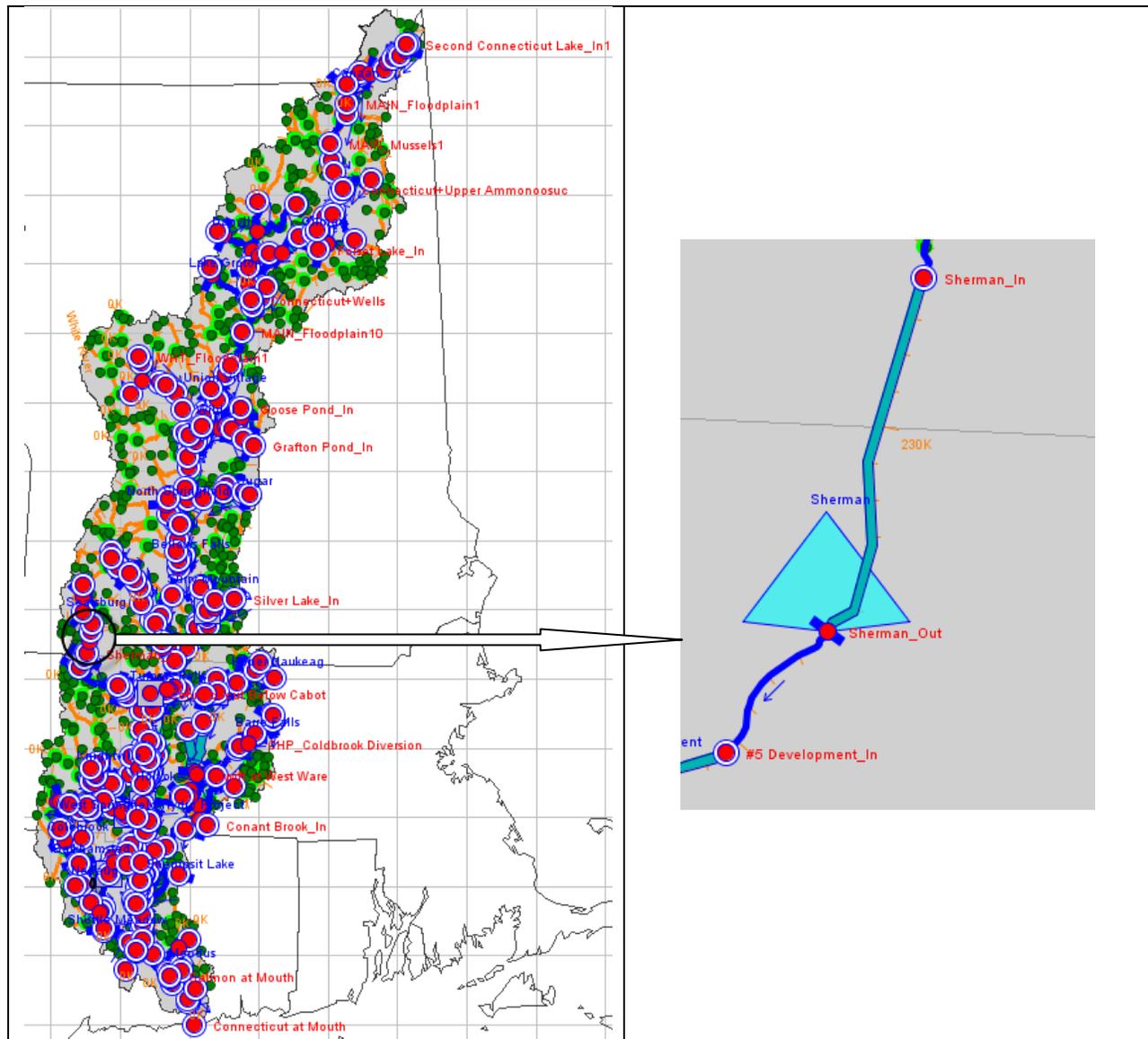


Figure 1: HEC-ResSim Map Display Showing Location of Sherman



Figure 2: Photo of Sherman dam

## II. Physical Characteristics

The physical characteristics of the reservoir are separated between the Pool and the Dam in the HEC-ResSim model. The elevation-storage-area defines the pool as shown in Figure 3<sup>87</sup>. The dam consists of three types of outlets: (1) controlled spillway, (2) uncontrolled outlet, and power plant as shown in Figure 4.

.

---

<sup>87</sup> Data provided by TransCanada

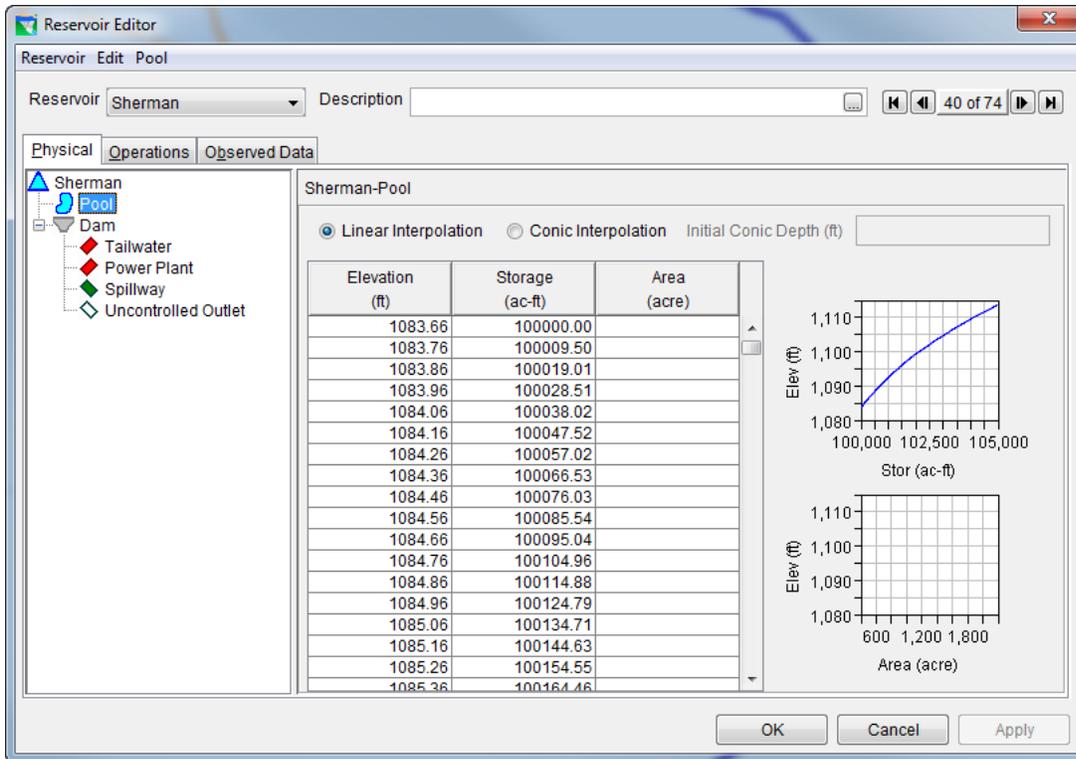


Figure 3: Reservoir Editor: Physical Tab -- Pool

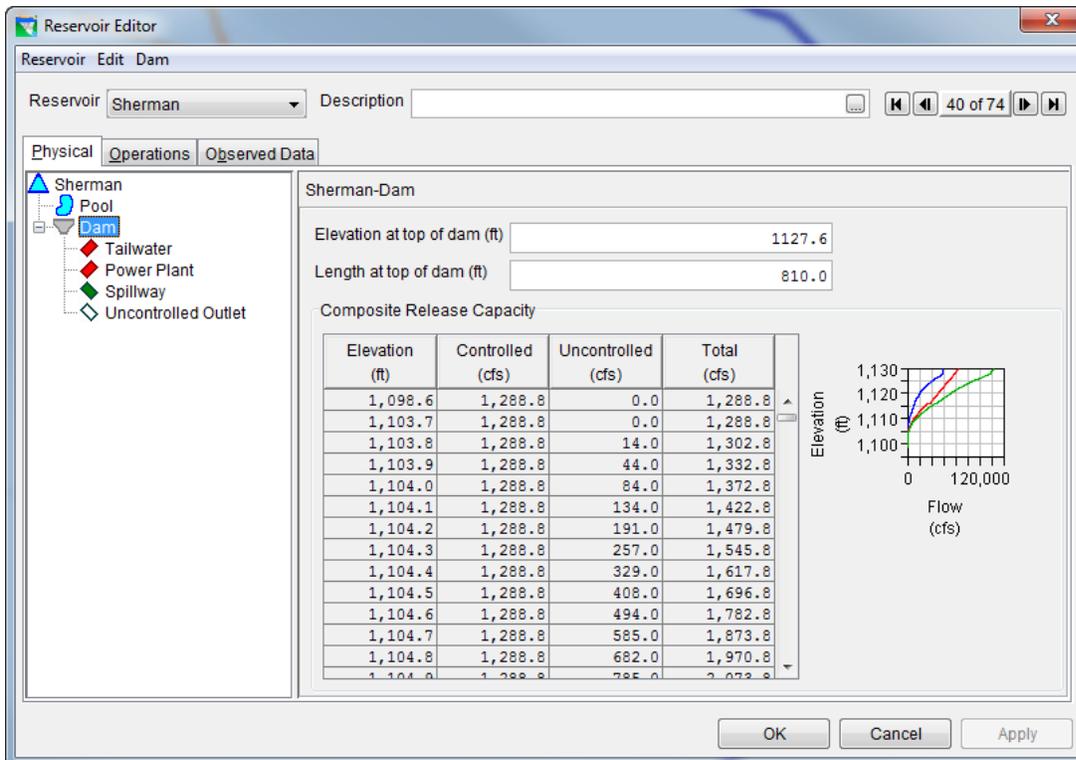


Figure 4: Reservoir Editor: Physical Tab -- Dam



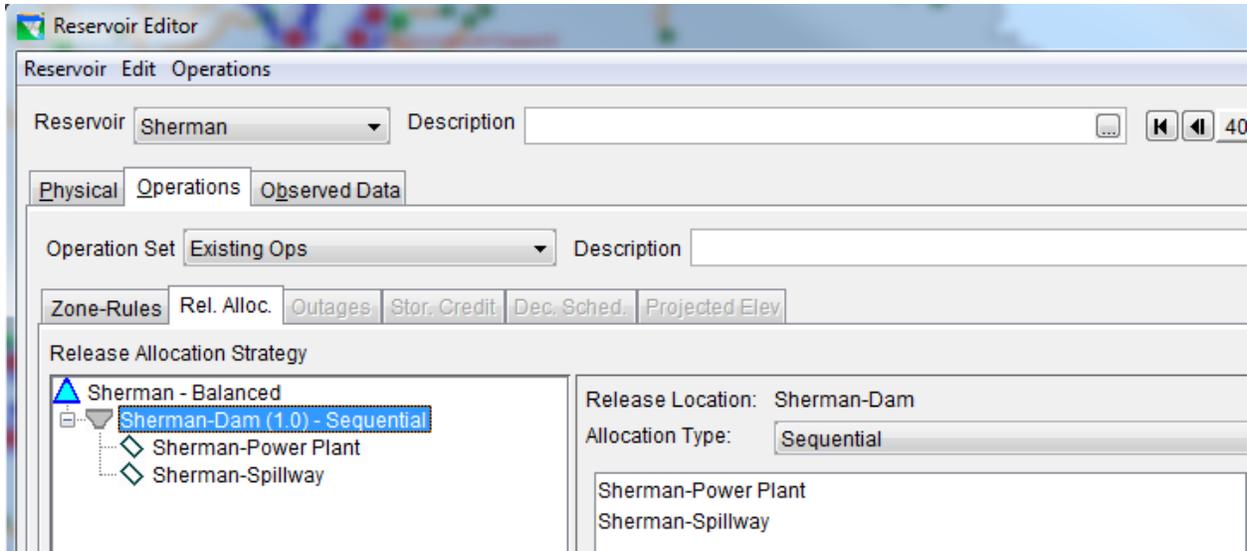


Figure 6: Reservoir Editor: Operations Tab – Existing Ops OpSet – Release Allocation

## B. Rule Illustrations

Figure 7 shows a set of operational rules specified for each zone that reflects the operation set named Existing Ops<sup>88</sup>.

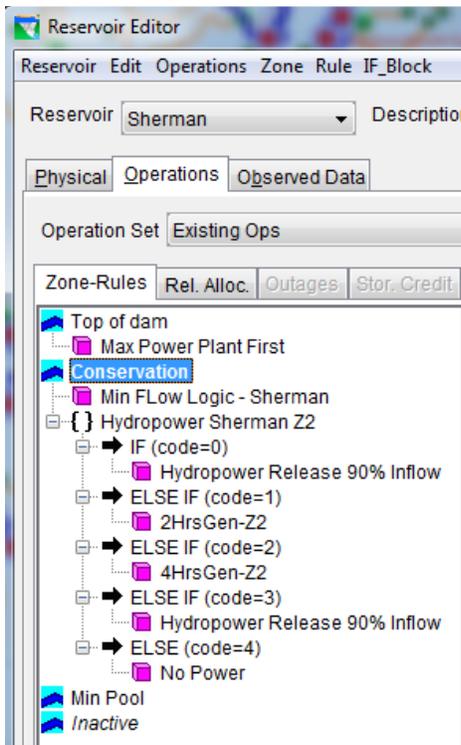


Figure 7: Reservoir Editor: Operations Tab – Existing Ops OpSet – Zones and Rules

<sup>88</sup> TransCanada. Deerfield River Operational Constraints. 2012.

## C. Rule Descriptions

### 1. Max Power Plant First

Figure 8 shows the content of “Max Power Plant First” rule. This rule forces the inflow to pass through the power plant first until it reaches the maximum plant capacity.

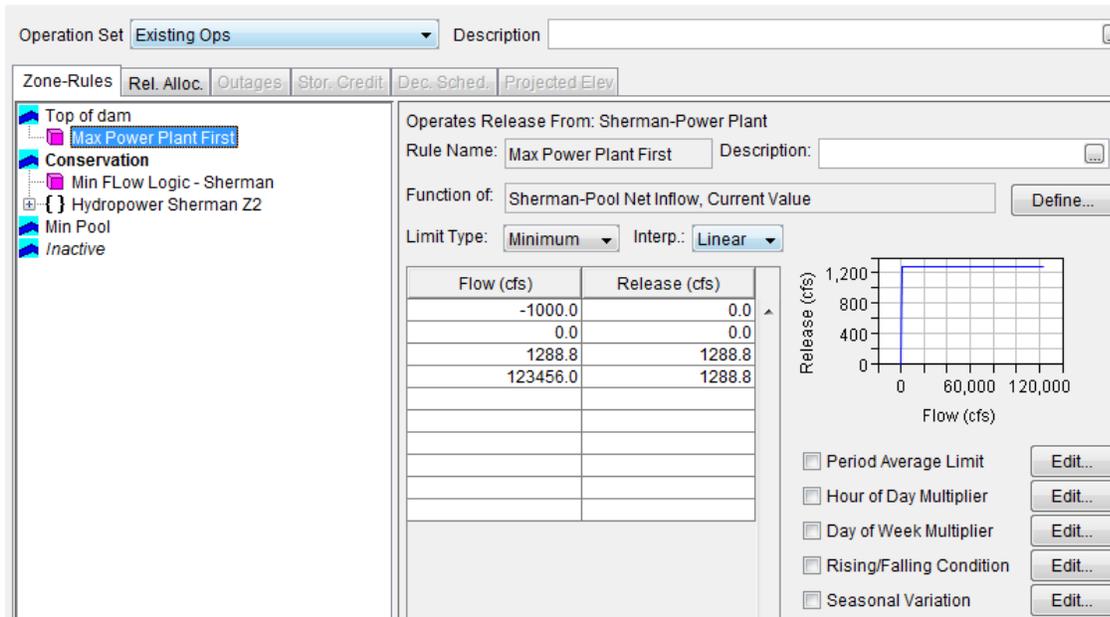


Figure 8: Reservoir Editor: Operations Tab – Existing Ops OpSet – Max Power Plant First

### 2. Min Flow Logic Sherman

This rule represents the minimum release from reservoir as a function of Inflow. The content of the rule is shown in Figure 9.

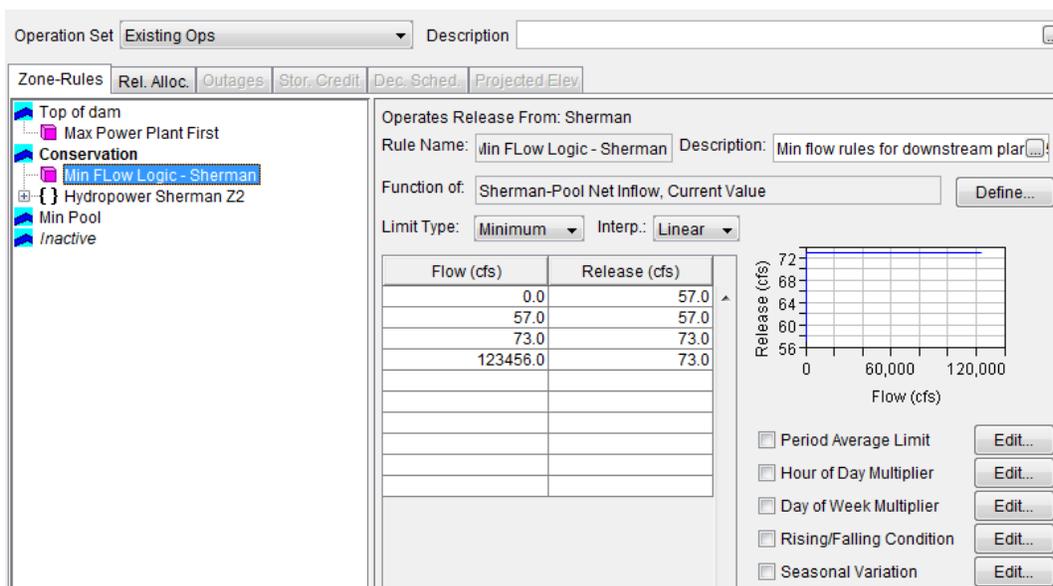


Figure 9: Reservoir Editor: Operations Tab – Existing Ops OpSet – Min Flow Logic Sherman

### 3. Hydropower Sherman Z2

This rule represents power strategy applied for Sherman reservoir. The content of the rule is shown in Figure 10.

The figure displays three sequential screenshots of a software interface for configuring a rule. Each screenshot has a common top section with 'Operation Set' set to 'Existing Ops' and a 'Description' field.

**Top Screenshot:** Shows a tree view on the left with 'Hydropower Sherman Z2' selected. The right pane shows 'Operates Release From: Sherman' and a table of rule codes:

Type	Name	Description
IF	code=0	
ELSE IF	code=1	
ELSE IF	code=2	
ELSE IF	code=3	
ELSE	code=4	

**Middle Screenshot:** Shows the 'IF Conditional' configuration. The condition is 'code=0'. Below is a table for defining the condition:

Value1	Value2
Sherman_Volume	= 0

Buttons for 'Add Cond.', 'Del. Cond.', 'Move Up', and 'Move Down' are visible.

**Bottom Screenshot:** Shows the 'Function of' configuration. The rule name is 'Hydropower Release 90% Inflow'. The function is 'Sherman-Pool Net Inflow, Current Value'. The limit type is 'Minimum' and the interpolation is 'Linear'. A table and a graph illustrate the relationship:

Flow (cfs)	Release (cfs)
0.0	0.0
100000.0	90000.0

The graph shows a linear relationship between Flow (cfs) on the x-axis (0 to 100,000) and Release (cfs) on the y-axis (0 to 90,000).

Operation Set: Existing Ops Description:

Zone-Rules: Rel. Alloc. Outages Stor. Credit Dec. Sched. Projected Elev

- Top of dam
  - Max Power Plant First
  - Conservation
    - Min FLOW Logic - Sherman
      - Hydropower Sherman Z2
        - IF (code=0)
          - Hydropower Release 90% Inflow
          - ELSE IF (code=1)
            - 2HrsGen-Z2
            - ELSE IF (code=2)
              - 4HrsGen-Z2
              - ELSE IF (code=3)
                - Hydropower Release 90% Inflow
                - ELSE (code=4)
                  - No Power

Operates Release From: Sherman-Power Plant

ELSE IF Conditional: code=1 Description:

| Value1         |   | Value2 |
|----------------|---|--------|
| Sherman_Volume | = | 1      |

Add Cond. Del. Cond. Move Up Move Down

Operation Set: Existing Ops Description:

Zone-Rules: Rel. Alloc. Outages Stor. Credit Dec. Sched. Projected Elev

- Top of dam
  - Max Power Plant First
  - Conservation
    - Min FLOW Logic - Sherman
      - Hydropower Sherman Z2
        - IF (code=0)
          - Hydropower Release 90% Inflow
          - ELSE IF (code=1)
            - 2HrsGen-Z2
            - ELSE IF (code=2)
              - 4HrsGen-Z2
              - ELSE IF (code=3)
                - Hydropower Release 90% Inflow
                - ELSE (code=4)
                  - No Power
      - Min Pool
      - Inactive

Operates Release From: Sherman-Power Plant

Hydropower - Power Guide Curve Rule: 2HrsGen-Z2

Description:

Zone at Top of Power Pool: Conservation

Zone at Bottom of Power Pool: Min Pool

| % Power Storage | Plant Factor (%) |
|-----------------|------------------|
| 0.0             | 0.0              |
| 100.0           | 8.33             |

Power Generation Pattern...

Operation Set: Existing Ops Description:

Zone-Rules: Rel. Alloc. Outages Stor. Credit Dec. Sched. Projected Elev

- Top of dam
  - Max Power Plant First
  - Conservation
    - Min FLOW Logic - Sherman
      - Hydropower Sherman Z2
        - IF (code=0)
          - Hydropower Release 90% Inflow
          - ELSE IF (code=1)
            - 2HrsGen-Z2
            - ELSE IF (code=2)
              - 4HrsGen-Z2
              - ELSE IF (code=3)
                - Hydropower Release 90% Inflow
                - ELSE (code=4)
                  - No Power

Operates Release From: Sherman-Power Plant

ELSE IF Conditional: code=2 Description:

| Value1         |   | Value2 |
|----------------|---|--------|
| Sherman_Volume | = | 2      |

Add Cond. Del. Cond. Move Up Move Down





The screenshot shows the State Variable Editor for a variable named 'Sherman\_Volume'. The code is as follows:

```

1 # Create a code to track the available water for generating power
2
3 #The code is summing up the current Inflow and previous storage in each timestep, compare it to the volume needed for
4 #generating 2 and 4 hours power and to the spillway storage minus inactive storage and then decide how much to release.
5
6 # Code =0: I+S >S(spillway storage)-S(inactive storage)
7 # code =1:0< I+S<V(2hrs.Gen)
8 # code =2: V(2hrs.Gen)<I+S<V(4hrs.Gen)
9 # code =3: V(4hrs.Gen)<I+S
10
11 # S(spillway storage)-S(inactive storage)=3593-1733.5=1859.5(acf)
12 #outlet capacity=1288.8(cfs)
13 #V(2hrs.Gen)=(2*outlet capacity)*0.082=211.36(acf)
14 #V(4hrs.Gen)=(4*outlet capacity)*0.082=422.72(acf)
15
16 from hec.model import RunTimeStep
17
18 Inflow_TS=network.getTimeSeries("Reservoir","Sherman", "Pool", "Flow-IN NET")
19 Inflow= Inflow_TS.getCurrentValue(currentRunTimeStep)
20 Inflow_acf=Inflow*1.98
21
22 Storage_TS = network.getTimeSeries("Reservoir","Sherman", "Pool", "Stor")
23 Storage=Storage_TS.getPreviousValue(currentRunTimeStep)
24
25 Volume=Inflow_acf+(Storage-1733.5)
26
27 if Volume >= 1859.5:
28     Code=0
29 elif 0<Volume <=211.36 :
30     Code=1
31 elif 211.36<Volume <=422.72:
32     Code=2
33 elif 422.72<Volume<1859.5:
34     Code=3
35 else:
36     Code=4
37
38 currentVariable.setValue(currentRunTimeStep,Code)

```

Figure 11: State Variable Editor: Sherman\_Volume

## Shuttle Meadow

### II. Overview

Shuttle Meadow dam is located on the upper reaches of Willow Brook in the towns of New Britain and Southington, CT. The dam is owned and operated by the two towns and is used for water supply.

Figure 1 shows the location of Shuttle Meadow dam as it is represented in the HEC-ResSim model. Figure 2 shows a photo of Shuttle Meadow dam.

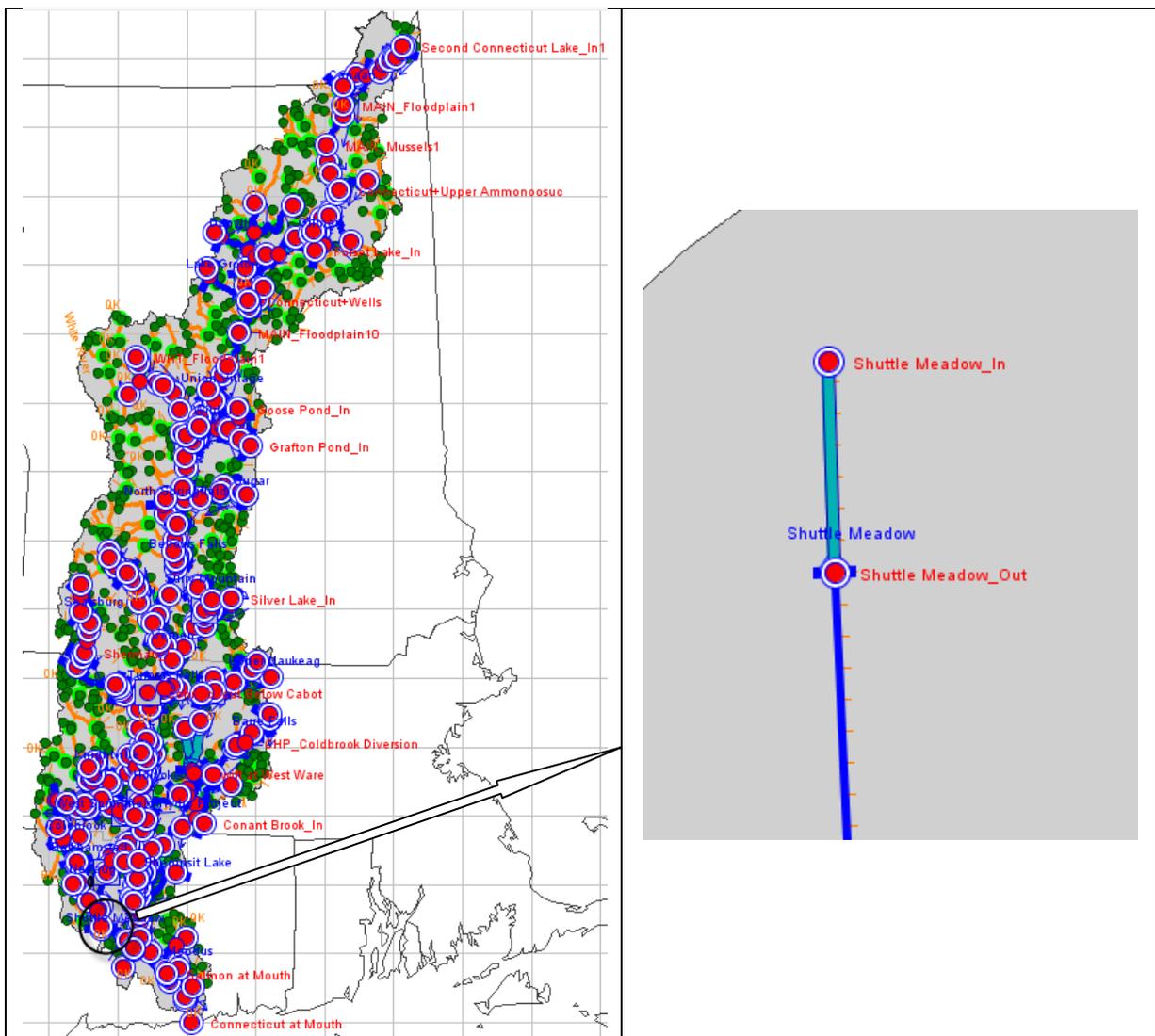


Figure 1: HEC-ResSim Map Display Showing Location of Shuttle meadow



**Figure 2: Photo of Shuttle Meadow dam.**

## **II. Physical Characteristics**

The physical characteristics of the reservoir are separated between the Pool and the Dam in the HEC-ResSim model. The elevation-storage-area defines the pool as shown in Figure 3<sup>89</sup>. The dam consists of an uncontrolled spillway as shown in Figure 4.

---

<sup>89</sup> Data provided by the Town of New Britain.

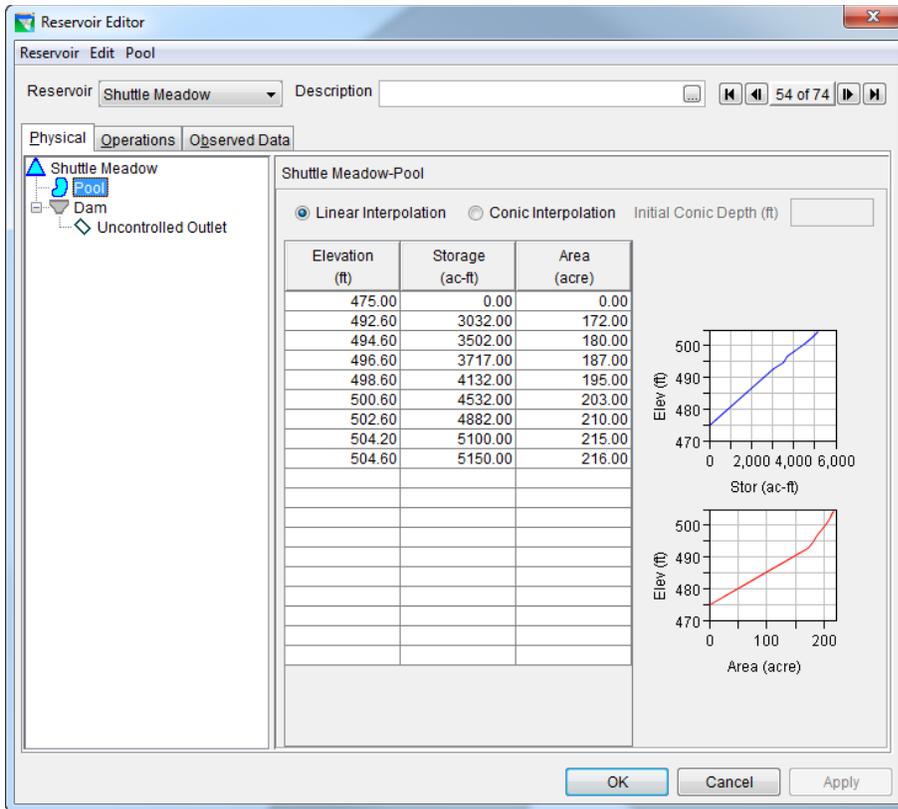


Figure 3: Reservoir Editor: Physical Tab -- Pool

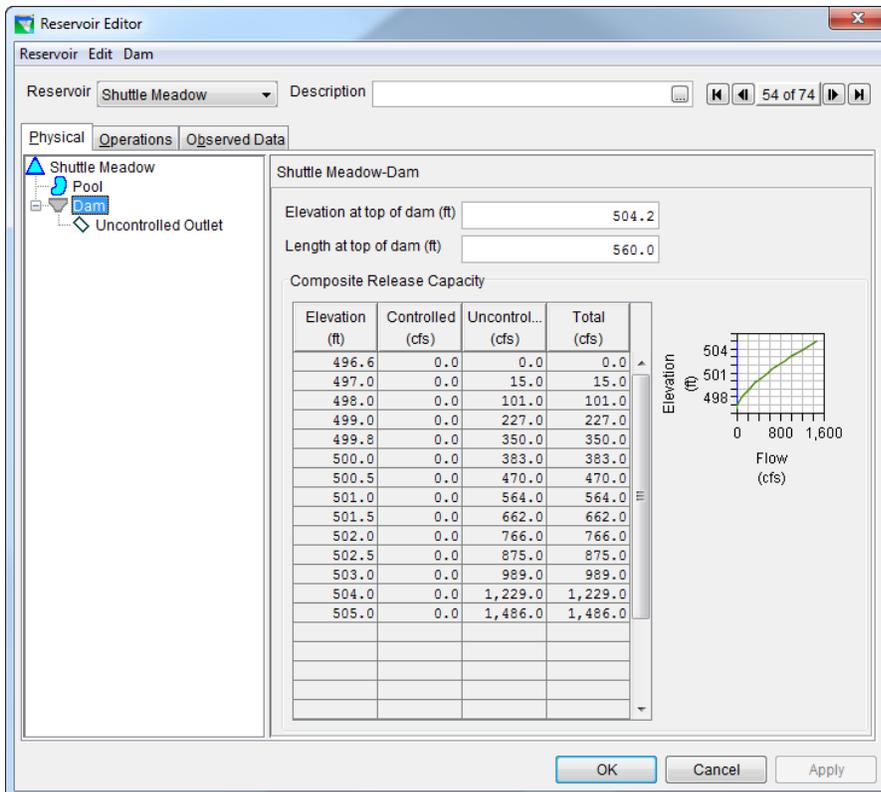


Figure 4: Reservoir Editor: Physical Tab -- Dam



## Silver Lake

### I. Overview

Silver Lake dam is located in the Town of Harrisville, NH and forms the headwaters of Minnewawa Brook. This dam is owned and operated by the State of New Hampshire Water Resources Board. It is primarily used for recreation with also some flood control benefits.

Figure 1 shows the location of Silver lake dam as it is represented in the HEC-ResSim model. Figure 2 shows a photo of Silver Lake dam.

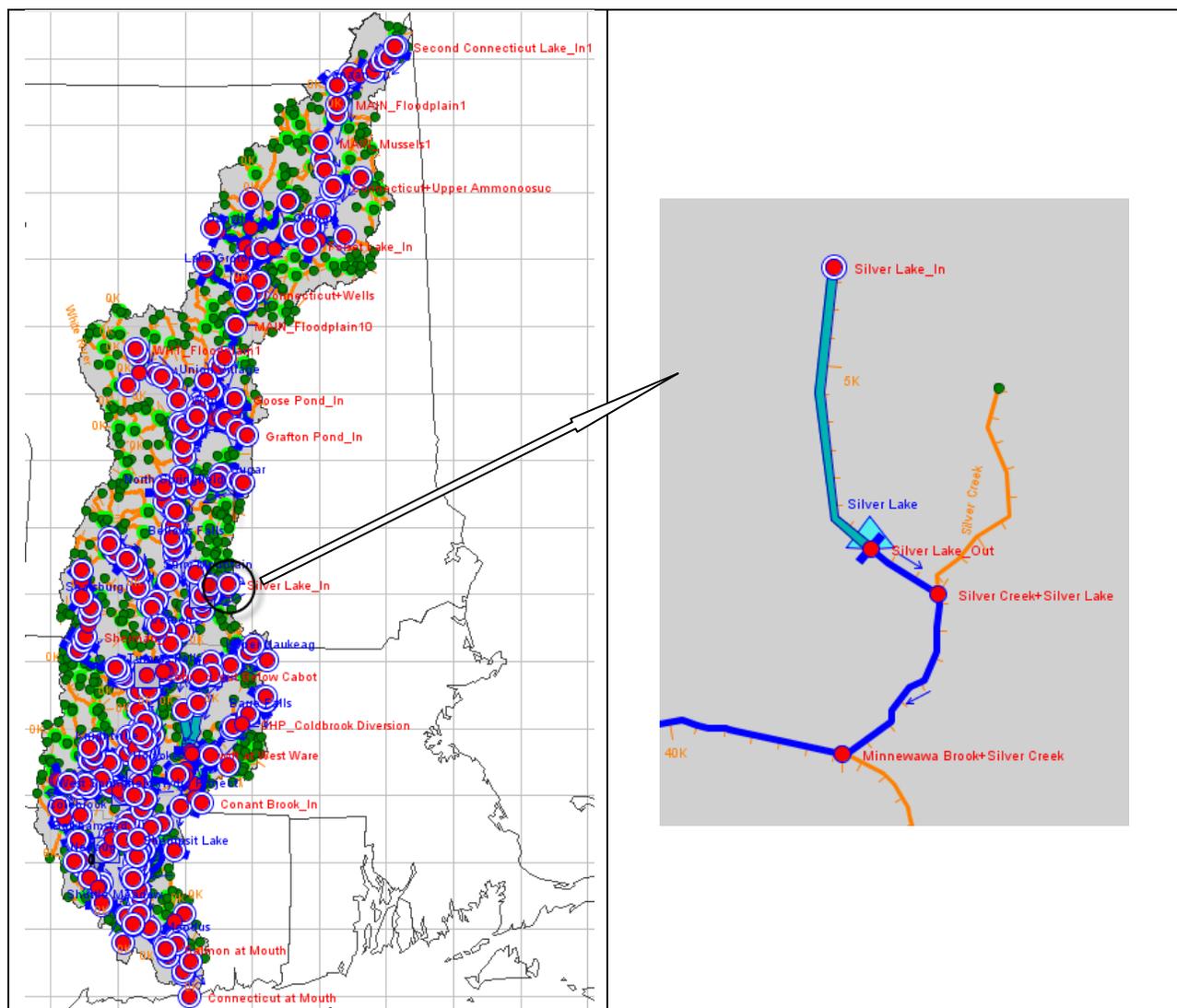


Figure 1: HEC-ResSim Map Display Showing Location of Silver lake



Figure 2: Photo of Silver Lake

## II. Physical Characteristics

The physical characteristics of the reservoir are separated between the Pool and the Dam in the HEC-ResSim model. The elevation-storage-area defines the pool as shown in Figure 3<sup>90</sup>. The dam consists of a controlled and an uncontrolled outlet as shown in Figure 4<sup>91</sup>.

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<sup>90</sup> NHDams Data Sheet. Silver Lake. 2007

<sup>91</sup> New Hampshire Water Resources Board. 1978

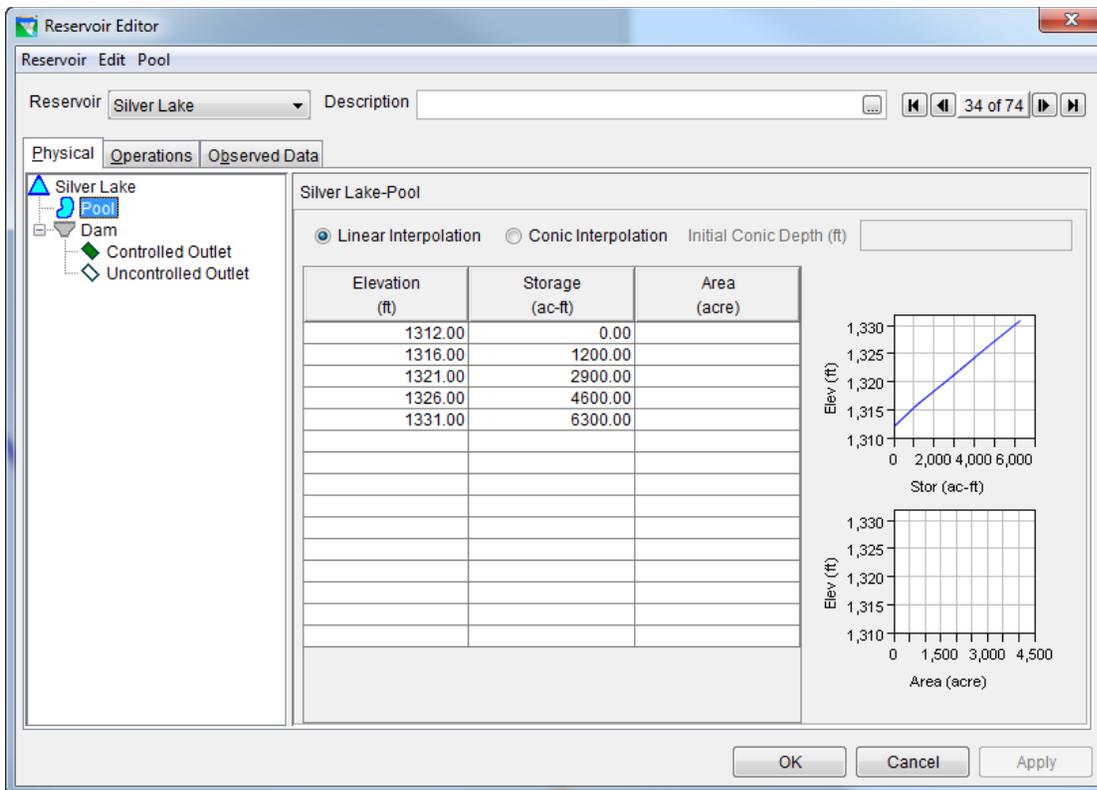


Figure 3: Reservoir Editor: Physical Tab -- Pool

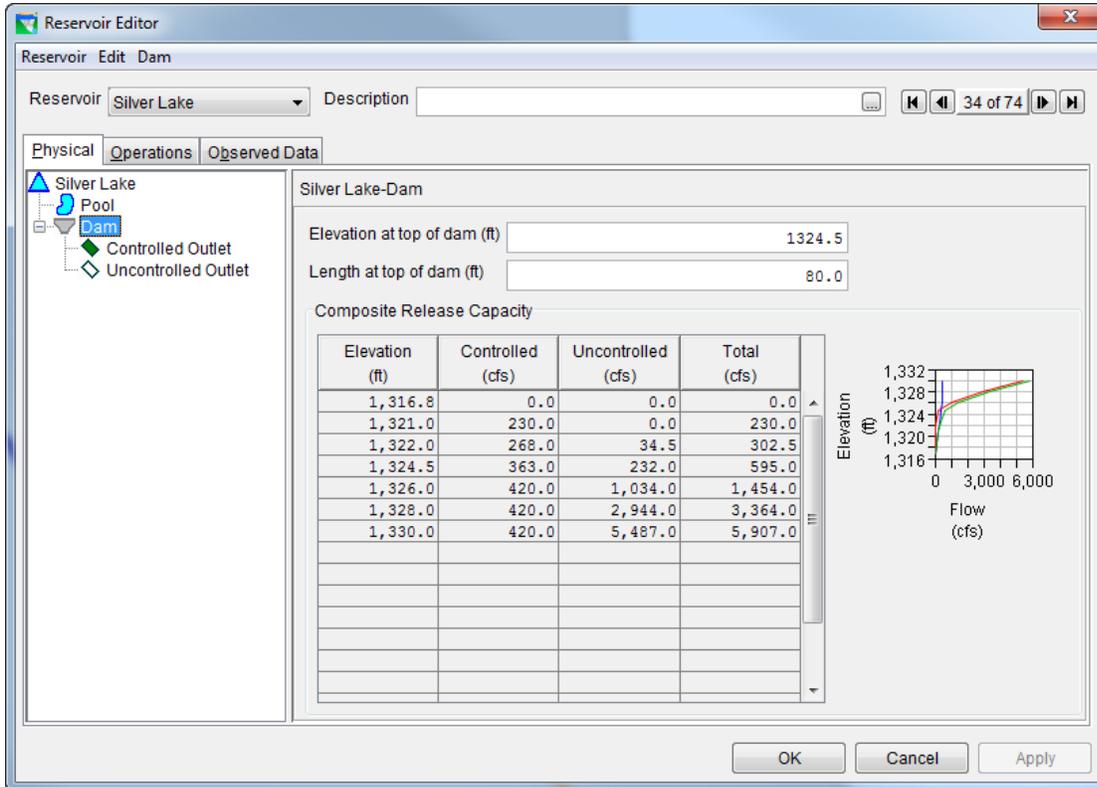


Figure 4: Reservoir Editor: Physical Tab -- Dam

### III. Operations

#### A. Operation Set

Zones are used to define the operational storage in the reservoir to determine the reservoir release through analysis of the rules contained within each zone. Figure 5 shows the definition of Bashan’s “Guide Curve” operational zones, which consist of zones of Flood Control (1322 ft), Conservation (1318-1321 ft), and Inactive zone (1315 ft)<sup>1</sup>.

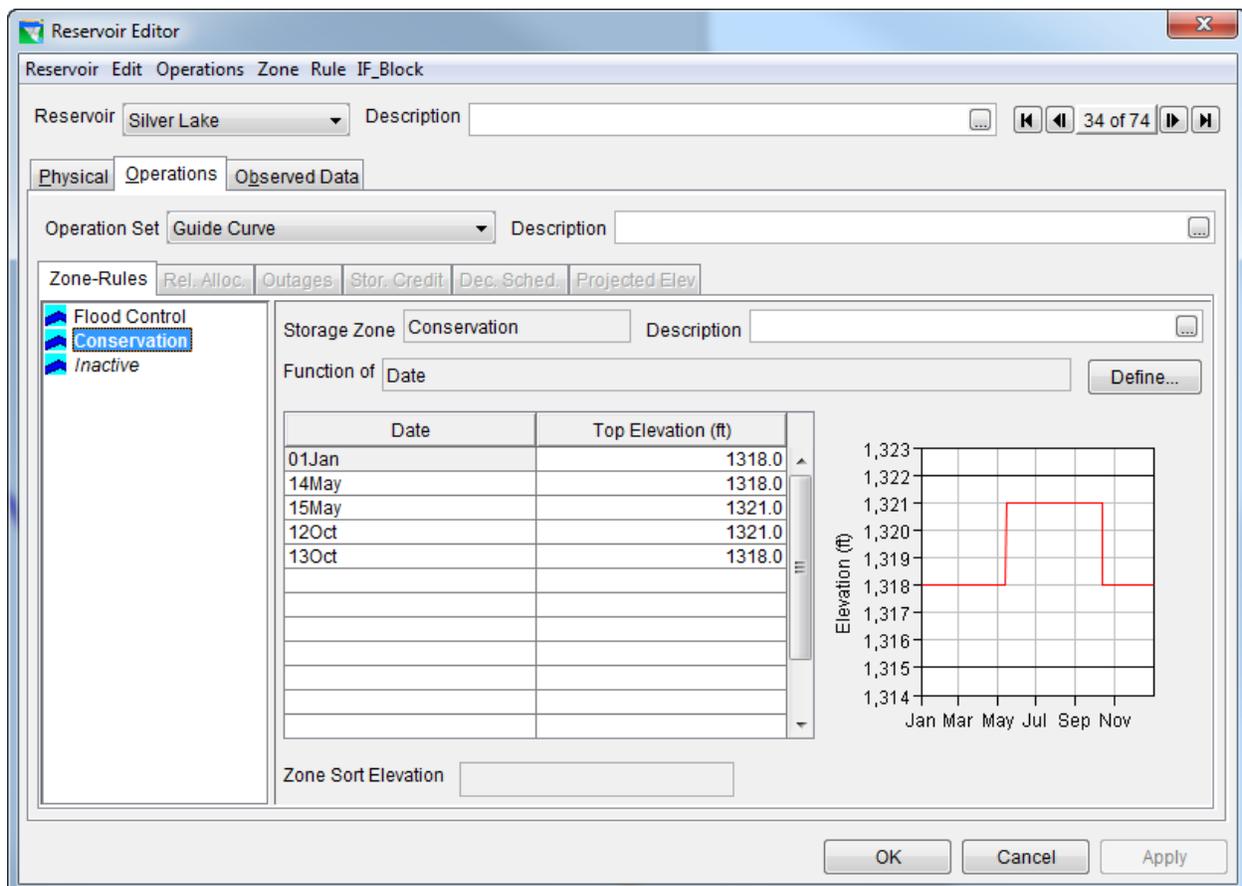


Figure 5: Reservoir Editor: Operations Tab – Guide Curve OpSet

#### B. Rule Illustrations

The operation set for Silver Lake has no rules of operation making it a flow through reservoir. The pool elevation will remain at the top of conservation unless the inflow exceeds the total release capacity.

## Somerset

### I. Overview

Somerset dam is located on the East Branch of the Deerfield River, and is the furthest upstream. It is owned and operated by TransCanada Hydro Northeast Inc. as a storage reservoir to make releases to its downstream hydro facilities.

Figure 1 shows the location of Somerset Dam as it is represented in the HEC-ResSim model. Figure 2 shows a photo from Somerset dam.

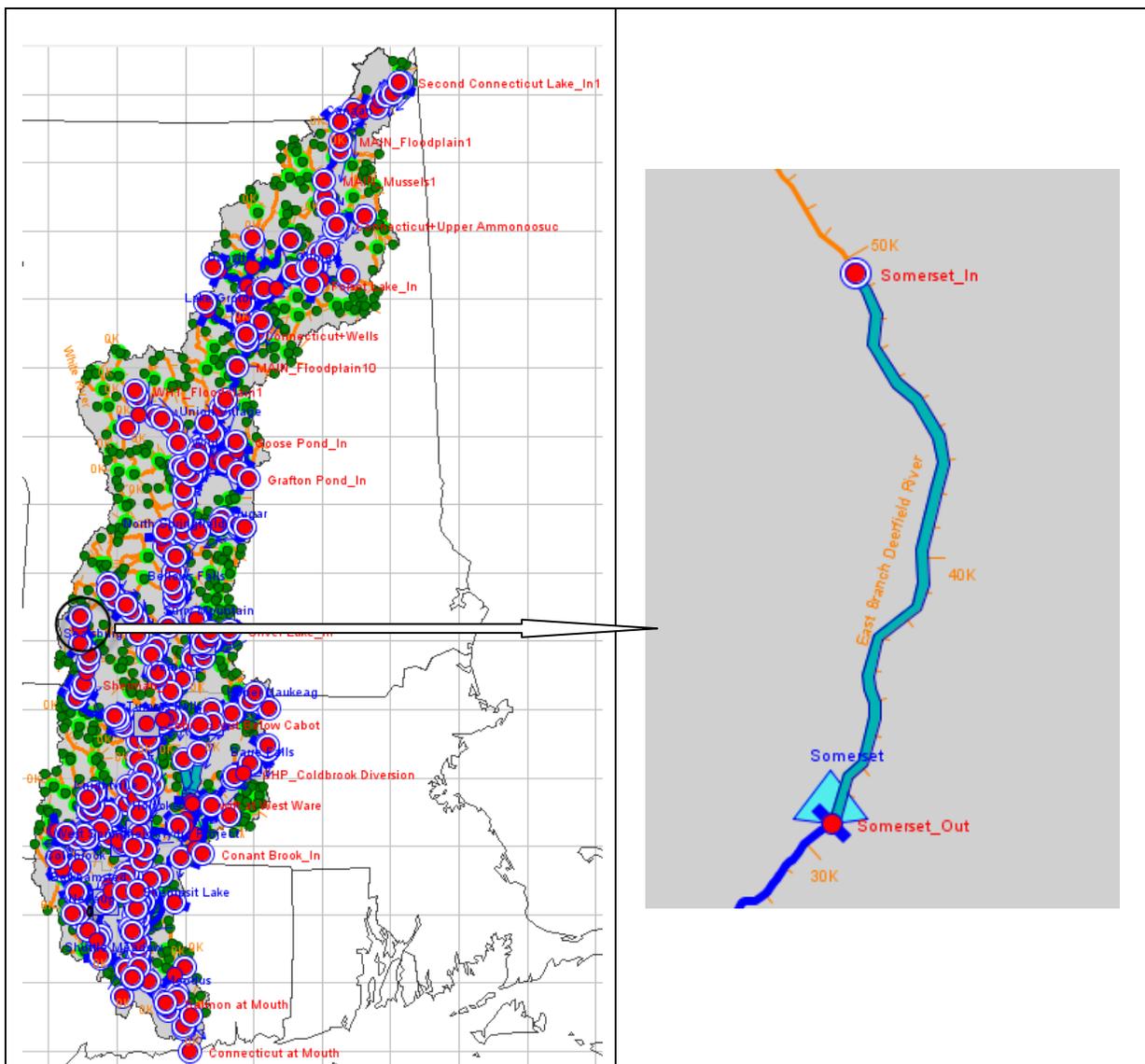


Figure 1: HEC-ResSim Map Display Showing Location of Somerset



**Figure 2: Photo of Somerset Dam**

## **II. Physical Characteristics**

The physical characteristics of the reservoir are separated between the Pool and the Dam in the HEC-ResSim model. The elevation-storage-area defines the pool as shown in Figure 3<sup>92</sup>. The dam consists of four types of outlets: (1) controlled outlet, (2) uncontrolled outlet, (3) 14 inch valve, and (4) 42 inch valve as shown in Figure 4.

---

<sup>92</sup> Data provided by TransCanada

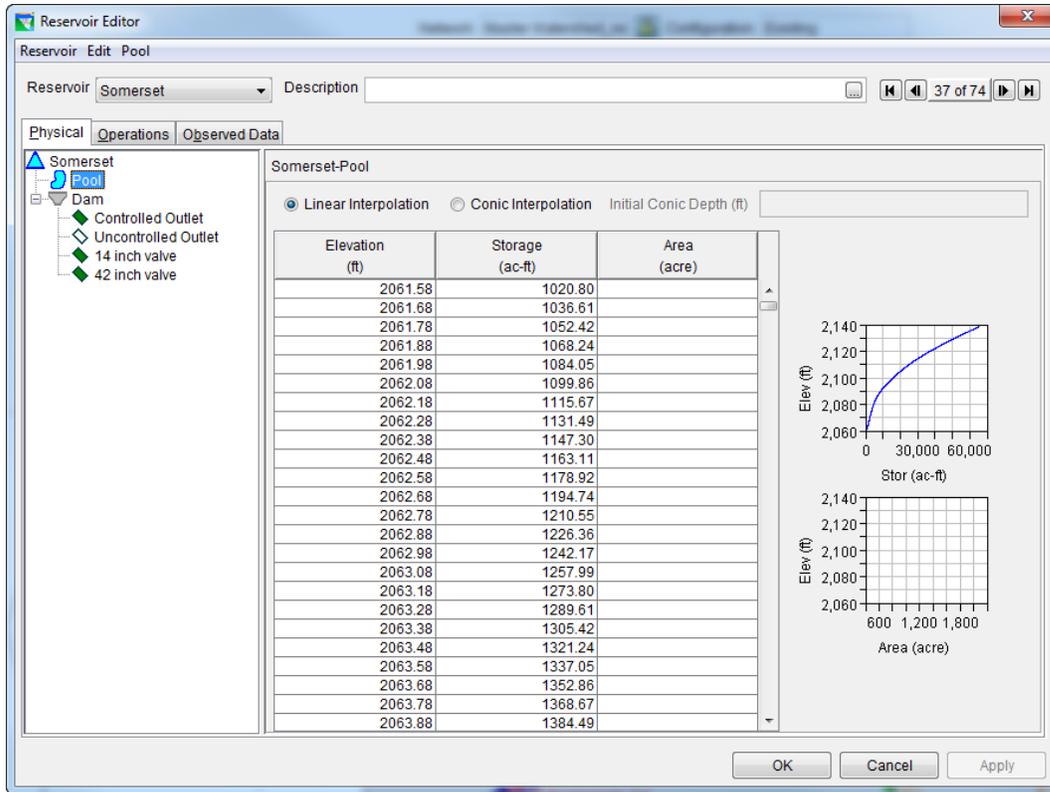


Figure 3: Reservoir Editor: Physical Tab -- Pool

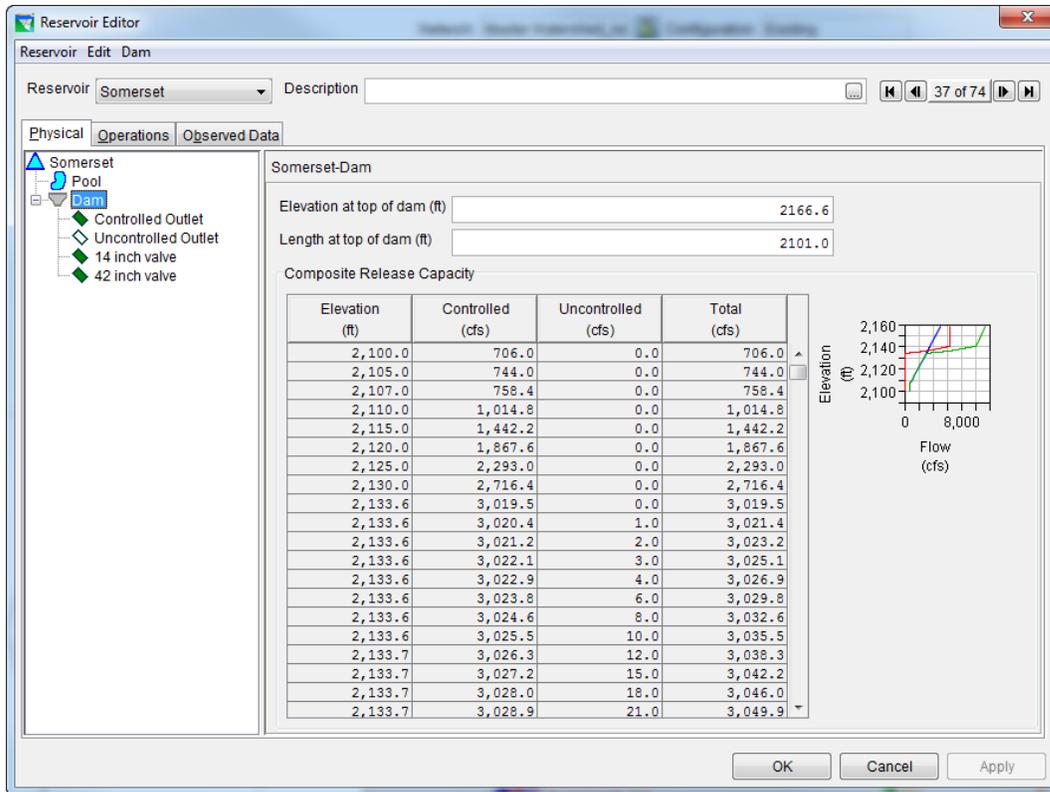


Figure 4: Reservoir Editor: Physical Tab -- Dam

### III. Operations

#### A. Operation Set

Zones are used to define the operational storage in the reservoir to determine the reservoir release through analysis of the rules contained within each zone. Figure 5 shows the definition of Somerset’s “ExistingOps” operational zones, which consist of zones of Top of dam (2166.6 ft), conservation (2131-2136.6 ft), Min Pool (2107 ft), and Inactive zone (2048.1 ft)<sup>1</sup>.

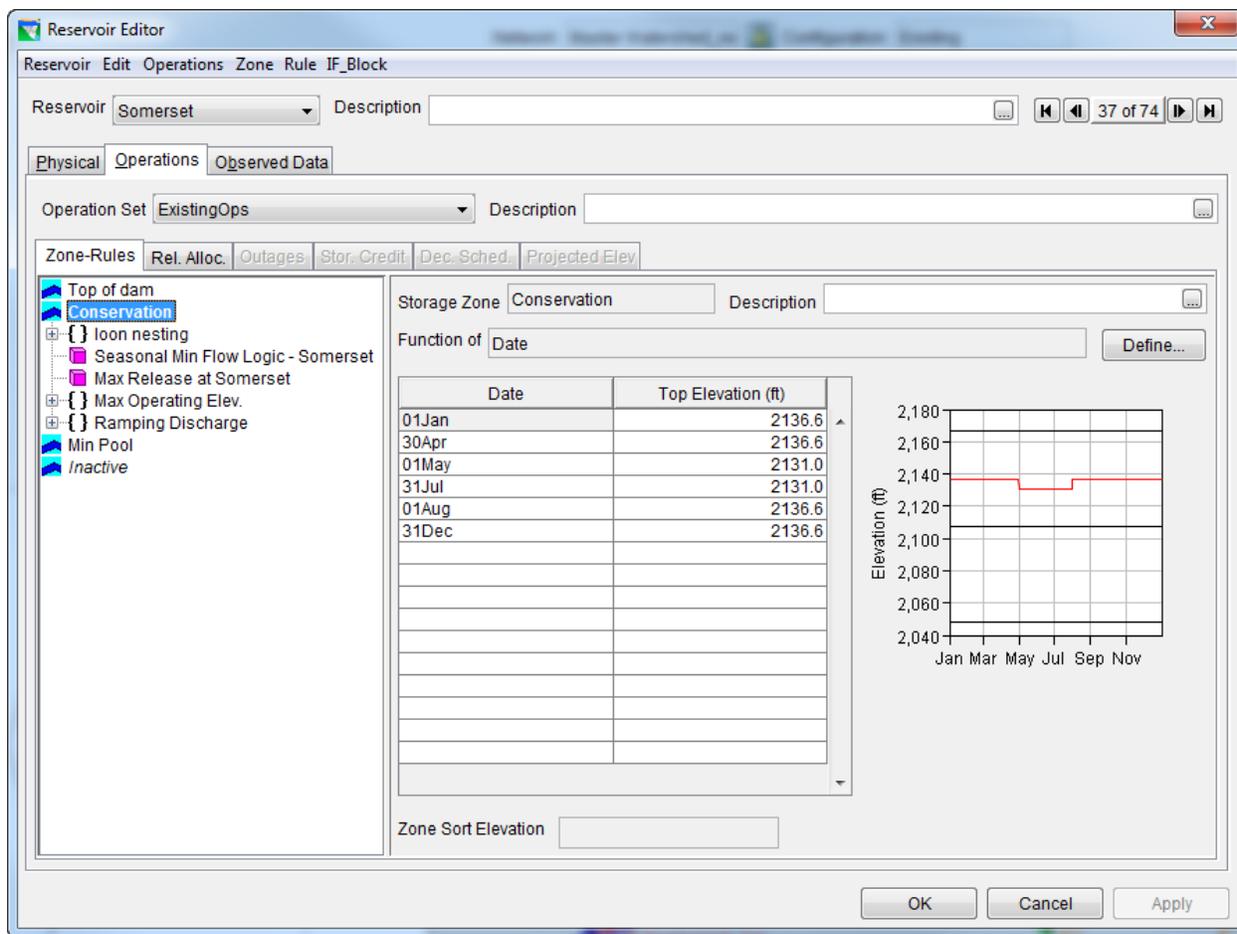


Figure 5 Reservoir Editor: Operations Tab –Existing Ops OpSet – Guide Curve

Figure 6 shows a sequential release allocation approach specified for available outlets along Harriman Dam. The available outlets are given an order of priority for release. The controlled outlet gets the release first until it reaches release capacity. The 14 inch valve and 42 incj valve gets the remainder of the release.

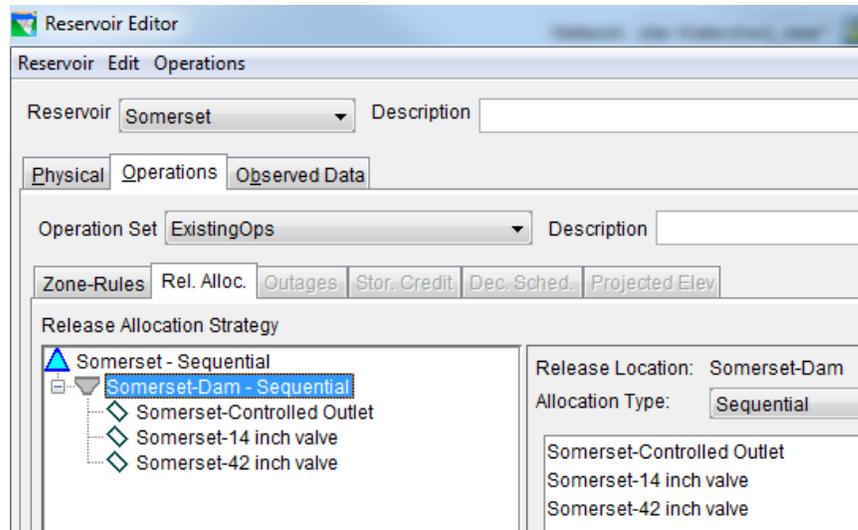


Figure 6: Reservoir Editor: Operations Tab – Existing Ops OpSet – Release Allocation

## B. Rule Illustrations

Figure 7 shows a set of operational rules specified for each zone that reflects the operation set named Existing Ops<sup>93</sup>.

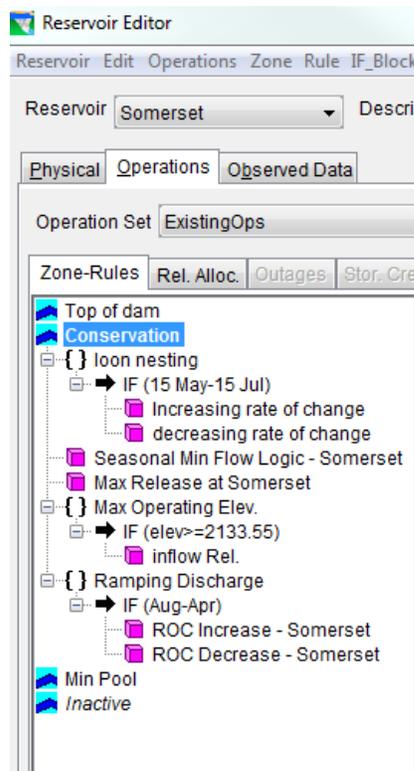


Figure 7: Reservoir Editor: Operations Tab – Existing Ops OpSet – Zones and Rules

<sup>93</sup> TransCanada. Deerfield River Operational Constraints. 2012.

## C. Rule Descriptions

### 1. Loon nesting

Figure 8 shows the content of “loon nesting” rule. This rule limits the maximum and minimum rate of elevation change to one foot per 1440 hours during May15-Jul 15.

Operation Set: ExistingOps Description:

Zone-Rules: Rel. Alloc. Outages Stor. Credit Dec. Sched. Projected Elev.

Operates Release From: Somerset

Name: loon nesting Description:

| Type | Name          | Description |
|------|---------------|-------------|
| IF   | 15 May-15 Jul |             |

Operation Set: ExistingOps Description:

Zone-Rules: Rel. Alloc. Outages Stor. Credit Dec. Sched. Projected Elev.

Operates Release From: Somerset

IF Conditional: 15 May-15 Jul Description:

|     | Value1            |    | Value2 |
|-----|-------------------|----|--------|
|     | Current Time Step | >= | 15May  |
| AND | Current Time Step | <= | 15Jul  |

Logical Operator:

Value 1: Time Series Value:

Opera...: =

Value 2: Constant Value:

Operation Set: ExistingOps Description:

Zone-Rules: Rel. Alloc. Outages Stor. Credit Dec. Sched. Projected Elev

Top of dam  
 Conservation  
 loon nesting  
 IF (15 May-15 Jul)  
 Increasing rate of change  
 decreasing rate of change  
 Seasonal Min Flow Logic - Somerset  
 Max Release at Somerset  
 Max Operating Elev.  
 IF (elev>=2133.55)  
 inflow Rel.  
 Ramping Discharge  
 IF (Aug-Apr)  
 ROC Increase - Somerset  
 ROC Decrease - Somerset  
 Min Pool  
 Inactive

Operates Release From: Somerset  
 Elevation Rate of Change Limit: Increasing rate of change  
 Description:   
 Function Of: Constant  
 Type: Increasing  
 Instantaneous  
 Period Average  
 Max Change of (ft) 1.0 over 1440 hours

---

Operation Set: ExistingOps Description:

Zone-Rules: Rel. Alloc. Outages Stor. Credit Dec. Sched. Projected Elev

Top of dam  
 Conservation  
 loon nesting  
 IF (15 May-15 Jul)  
 Increasing rate of change  
 decreasing rate of change  
 Seasonal Min Flow Logic - Somerset  
 Max Release at Somerset  
 Max Operating Elev.  
 IF (elev>=2133.55)  
 inflow Rel.  
 Ramping Discharge  
 IF (Aug-Apr)  
 ROC Increase - Somerset  
 ROC Decrease - Somerset  
 Min Pool  
 Inactive

Operates Release From: Somerset  
 Elevation Rate of Change Limit: decreasing rate of change  
 Description:   
 Function Of: Constant  
 Type: Decreasing  
 Instantaneous  
 Period Average  
 Max Change of (ft) 1.0 over 1440 hours

Figure 8: Reservoir Editor: Operations Tab – Existing Ops OpSet – loon nesting

## 2. Seasonal Min Flow Logic-Somerset

Figure 9 shows the content of “Seasonal Min Flow Logic-Somerset” rule. This rule represents the seasonal minimum flow from reservoir as a function of Inflow.

Operates Release From: Somerset

Rule Name: **Min Flow Logic - Somerset** Description: Water Quality Certification Document (Page 12) states al...

Function of: Somerset-Pool Net Inflow, Current Value

Limit Type: **Minimum** Interp.: **Linear**

| Flow (cfs) | Release (cfs) |       |       |       |       |       |
|------------|---------------|-------|-------|-------|-------|-------|
|            | 01Jan         | 01Mar | 01May | 01Aug | 01Oct | 01Nov |
| 0.0        | 100.0         | 30.0  | 9.0   | 12.0  | 30.0  | 100.0 |
| 9.0        | 100.0         | 30.0  | 9.0   | 12.0  | 30.0  | 100.0 |
| 12.0       | 100.0         | 30.0  | 12.0  | 12.0  | 30.0  | 100.0 |
| 123456.0   | 100.0         | 30.0  | 12.0  | 12.0  | 30.0  | 100.0 |

Release (cfs) vs Flow (cfs) graph showing a horizontal line at approximately 30 cfs.

Period Average Limit Edit...

Hour of Day Multiplier Edit...

Day of Week Multiplier Edit...

Rising/Falling Condition Edit...

Seasonal Variation Edit...

Figure 9: Reservoir Editor: Operations Tab – Existing Ops OpSet – Seasonal Min Flow Logic-Somerset

## 3. Max Release at Somerset

Figure 10 shows the content of “Max Release at Somerset” rule. This rule represents the seasonal maximum flow from reservoir based on Inflow.

Operates Release From: Somerset

Rule Name: **Max Release at Somerset** Description:

Function of: Somerset-Pool Net Inflow, Current Value

Limit Type: **Maximum** Interp.: **Linear**

| Flow (cfs) | Release (cfs) |          |        |
|------------|---------------|----------|--------|
|            | 01Jan         | 15May    | 16Jul  |
| 0.0        | 312.0         | 123456.0 | 312.0  |
| 312.0      | 312.0         | 123456.0 | 312.0  |
| 1000.0     | 1000.0        | 123456.0 | 1000.0 |
| 2000.0     | 2000.0        | 123456.0 | 2000.0 |

Release (cfs) vs Flow (cfs) graph showing a horizontal line at 120,000 cfs.

Period Average Limit Edit...

Hour of Day Multiplier Edit...

Day of Week Multiplier Edit...

Rising/Falling Condition Edit...

Seasonal Variation Edit...

Figure 10: Reservoir Editor: Operations Tab – Existing Ops OpSet – Max release at Somerset

#### 4. Max Operating Elev.

Figure 11 shows the content of “Max Operating Elev” rule. This rule makes the release equal to inflow when the pool elevation is higher than 2133.55.

The screenshot displays the configuration of the 'Max Operating Elev' rule within an 'ExistingOps' operation set. The interface is divided into several sections:

- Operation Set:** ExistingOps
- Zone-Rules:** Rel. Alloc., Outages, Stor. Credit, Dec. Sched., Projected Elev
- Tree View (Left):**
  - Top of dam
  - Conservation
    - loon nesting
      - IF (15 May-15 Jul)
        - Increasing rate of change
        - decreasing rate of change
      - Seasonal Min Flow Logic - Somerset
      - Max Release at Somerset
        - Max Operating Elev** (selected)
          - IF (elev>=2133.55)
            - inflow Rel.
      - Ramping Discharge
        - IF (Aug-Apr)
          - ROC Increase - Somerset
          - ROC Decrease - Somerset
    - Min Pool
    - Inactive

- Main Configuration Area (Right):**
- Name: Max Operating Elev.
- Description:

| Type | Name          | Description |
|------|---------------|-------------|
| IF   | elev>=2133.55 |             |
- Conditional Logic Editor (Bottom):**
- IF Conditional: elev>=2133.55
- Description:

| Value1                  | Value2     |
|-------------------------|------------|
| Somerset-Pool:Elevation | >= 2133.55 |

- Buttons: Add Cond., Del. Cond., Move Up, Move Down, Evaluate
- Logical Operator: [Dropdown]
- Value 1: Time Series [Dropdown] [Input Field] [Pick Value]
- Operat...: [=] [Dropdown]
- Value 2: Constant [Dropdown] [Input Field]

Operation Set: ExistingOps Description: [ ]

Zone-Rules: Rel. Alloc. Outages Stor. Credit Dec. Sched. Projected Elev

Top of dam  
 Conservation  
 { } loon nesting  
 IF (15 May-15 Jul)  
 Increasing rate of change  
 decreasing rate of change  
 Seasonal Min Flow Logic - Somerset  
 Max Release at Somerset  
 { } Max Operating Elev.  
 IF (elev >= 2133.55)  
 inflow Rel.  
 { } Ramping Discharge  
 IF (Aug-Apr)  
 ROC Increase - Somerset  
 ROC Decrease - Somerset  
 Min Pool  
 Inactive

Operates Release From: Somerset  
 Rule Name: inflow Rel. Description: [ ]  
 Function of: Somerset-Pool Net Inflow, Current Value Define...  
 Limit Type: Minimum Interp.: Linear

| Flow (cfs) | Release (cfs) |
|------------|---------------|
| 0.0        | 0.0           |
| 10000.0    | 10000.0       |
|            |               |
|            |               |
|            |               |
|            |               |
|            |               |
|            |               |
|            |               |
|            |               |

Release (cfs) 12,000 8,000 4,000 0  
 Flow (cfs) 0 2,000 4,000 6,000 8,000 10,000

Period Average Limit Edit...  
 Hour of Day Multiplier Edit...  
 Day of Week Multiplier Edit...  
 Rising/Falling Condition Edit...  
 Seasonal Variation Edit...

Figure 11: Reservoir Editor: Operations Tab – Existing Ops OpSet – Max Operating Elev.

### 5. Ramping Discharge

Figure 12 shows the content of “Ramping Discharge” rule. This rule limits the maximum increasing rate of release change to 4.1667 (cfs/hr) and the maximum decreasing rate of release change to 2.0833 (cfs/hr) during Aug-Apr.

The screenshot displays the configuration for the "Ramping Discharge" rule within the "ExistingOps" operation set. The interface is divided into two main sections.

**Left Panel (Tree View):** Shows a hierarchical list of rules. The "Ramping Discharge" rule is selected and highlighted in blue. It is located under the "Conservation" category, which also includes "loon nesting", "Seasonal Min Flow Logic - Somerset", "Max Release at Somerset", "Max Operating Elev.", "inflow Rel.", "ROC Increase - Somerset", and "ROC Decrease - Somerset".

**Right Panel (Configuration):** Shows the specific settings for the "Ramping Discharge" rule.
 

- Name:** Ramping Discharge
- Description:** per Deerfield schematic
- Operates Release From:** Somerset
- IF Conditional:** Aug-Apr
- Table:**

|     | Value1            |    | Value2 |
|-----|-------------------|----|--------|
| AND | Current Time Step | >= | 01Aug  |
|     | Current Time Step | <= | 30Apr  |
- Logical Operator:** (Dropdown menu)
- Value 1:** Time Series (Dropdown menu)
- Operat...:** = (Dropdown menu)
- Value 2:** Constant (Dropdown menu)

Operation Set: ExistingOps Description:

Zone-Rules: Rel. Alloc. Outages Stor. Credit Dec. Sched. Projected Elev

Top of dam  
 Conservation  
 loon nesting  
 IF (15 May-15 Jul)  
 Increasing rate of change  
 decreasing rate of change  
 Seasonal Min Flow Logic - Somerset  
 Max Release at Somerset  
 Max Operating Elev.  
 IF (elev>=2133.55)  
 inflow Rel.  
 Ramping Discharge  
 IF (Aug-Apr)  
 ROC Increase - Somerset  
 ROC Decrease - Somerset  
 Min Pool  
 Inactive

Operates Release From: Somerset  
 Release Rate of Change Limit: ROC Increase - Somerset  
 Description:   
 Function Of: Constant  
 Type: Increasing  
 Max Rate of Change (cfs/hr): 4.1667

---

Operation Set: ExistingOps Description:

Zone-Rules: Rel. Alloc. Outages Stor. Credit Dec. Sched. Projected Elev

Top of dam  
 Conservation  
 loon nesting  
 IF (15 May-15 Jul)  
 Increasing rate of change  
 decreasing rate of change  
 Seasonal Min Flow Logic - Somerset  
 Max Release at Somerset  
 Max Operating Elev.  
 IF (elev>=2133.55)  
 inflow Rel.  
 Ramping Discharge  
 IF (Aug-Apr)  
 ROC Increase - Somerset  
 ROC Decrease - Somerset  
 Min Pool  
 Inactive

Operates Release From: Somerset  
 Release Rate of Change Limit: ROC Decrease - Somerset  
 Description:   
 Function Of: Constant  
 Type: Decreasing  
 Max Rate of Change (cfs/hr): 2.0833

Figure 12: Reservoir Editor: Operations Tab – Existing Ops OpSet – Ramping Discharge

# Sugar

## I. Overview

Sugar dam is located on the Sugar River in the town of Newport, NH. It is owned and operated by Sweetwater Hydroelectric, Inc. and is used for hydropower generation.

Figure 1 shows the location of Sugar dam as it is represented in the HEC-ResSim model. Figure 2 shows a photo of Sugar dam.

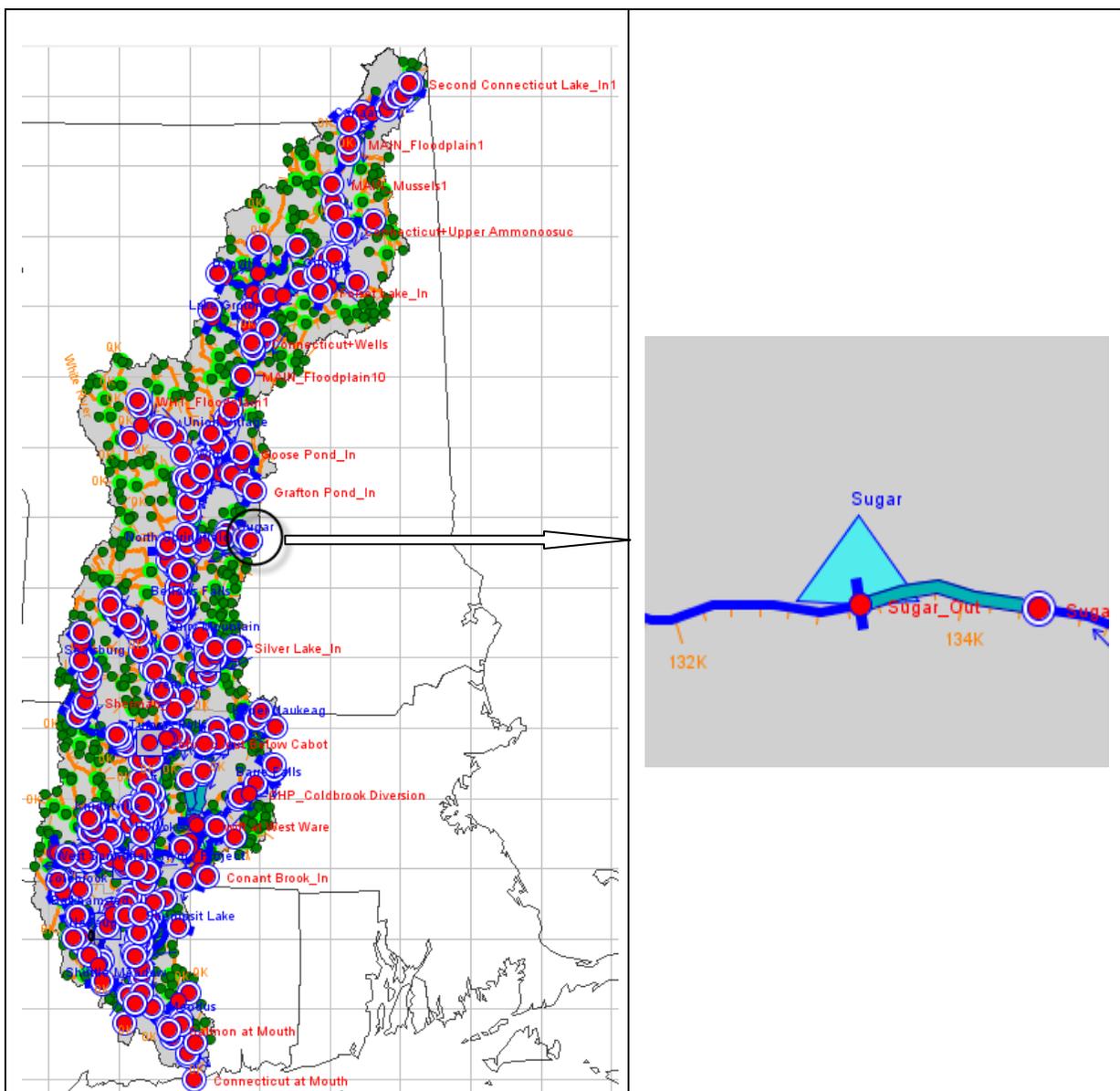


Figure 1: HEC-ResSim Map Display Showing Location of Sugar Dam



Figure 2: Photo of Sugar dam

## II. Physical Characteristics

The physical characteristics of the reservoir are separated between the Pool and the Dam in the HEC-ResSim model. The elevation-storage-area defines the pool as shown in Figure 3<sup>94</sup>. The dam consists of three types of outlets: (1) controlled Waste Sluice, (2) uncontrolled outlet, and (3) controlled Inlet pipe for pump power generation as shown in Figure 4.

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<sup>94</sup> NHDams Data Sheet. Sugar River Mill Dam. 2010.



### III. Operations

#### A. Operation Set

Zones are used to define the operational storage in the reservoir to determine the reservoir release through analysis of the rules contained within each zone. Figure 5 shows the definition of Sugar’s “Guide Curve” operational zones, which consist of zones of Flood Control (1094.5 ft), Conservation (1090.5 ft), and Inactive zone (1076 ft).

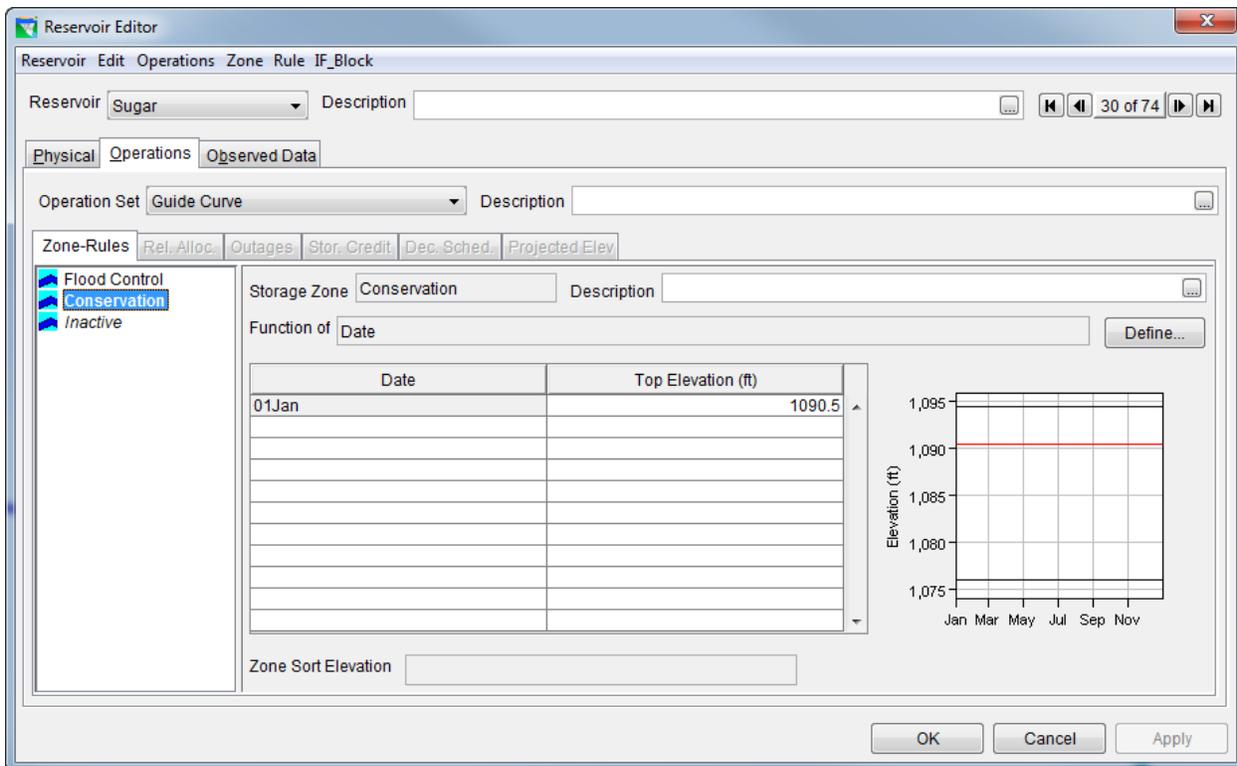


Figure 5: Reservoir Editor: Operations Tab –Guide Curve OpSet – Guide Curve

#### B. Rule Illustrations

The operation set for Sugar has no rules of operation making it a flow through reservoir. The pool elevation will remain at the top of conservation unless the inflow exceeds the total release capacity.

# Surry Mountain

## I. Overview

Surry Mountain Dam is a dam upstream of Keene, New Hampshire on the Ashuelot River. It was constructed by the US Army Corps of Engineers in 1941 and is still owned and operated by the Corps. It is primarily used for flood control purposes but also for recreation.

Figure 1 shows the location of Surry Mountain Dam as it is represented in the HEC-ResSim model. Figure 2 shows a photo of the dam.

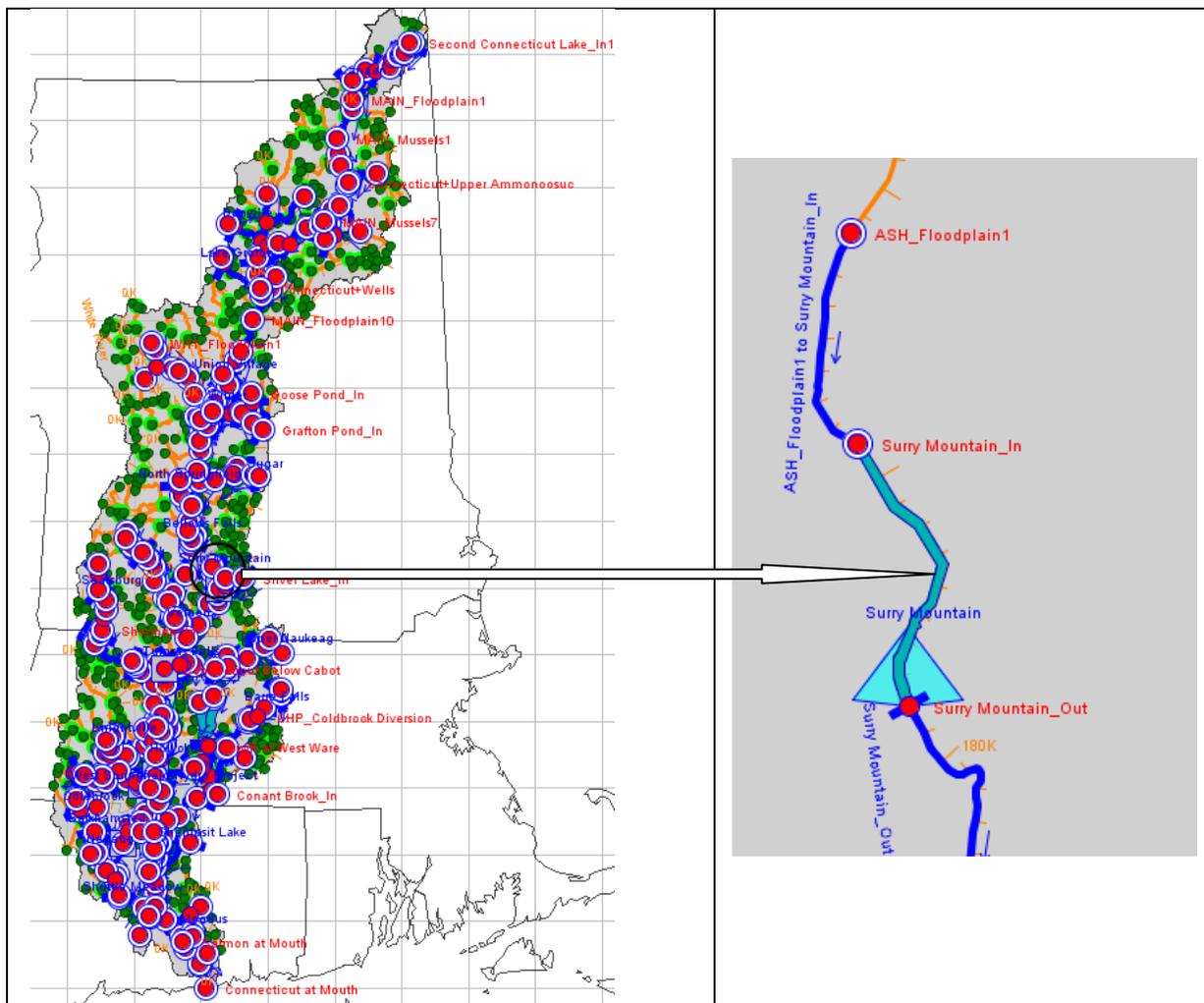


Figure 1: HEC-ResSim Map Display Showing Location of Surry Mountain dam



**Figure 2: Photo of Surry Mountain Dam**

## **II. Physical Characteristics**

The physical characteristics of the reservoir are separated between the Pool and the Dam in the HEC-ResSim model. The elevation-storage-area defines the pool as shown in Figure 3. The dam consists of two types of outlets: (1) controlled Broome gates, and (2) uncontrolled spillway, as shown in Figure 4. All physical and operations data were provided by US Army Corps New England District, through both a previously created ResSim model and the Reservoir Regulation Team website<sup>95</sup>.

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<sup>95</sup> [http://rsgisias.crrel.usace.army.mil/nae/cwms\\_map.map\\_index](http://rsgisias.crrel.usace.army.mil/nae/cwms_map.map_index)

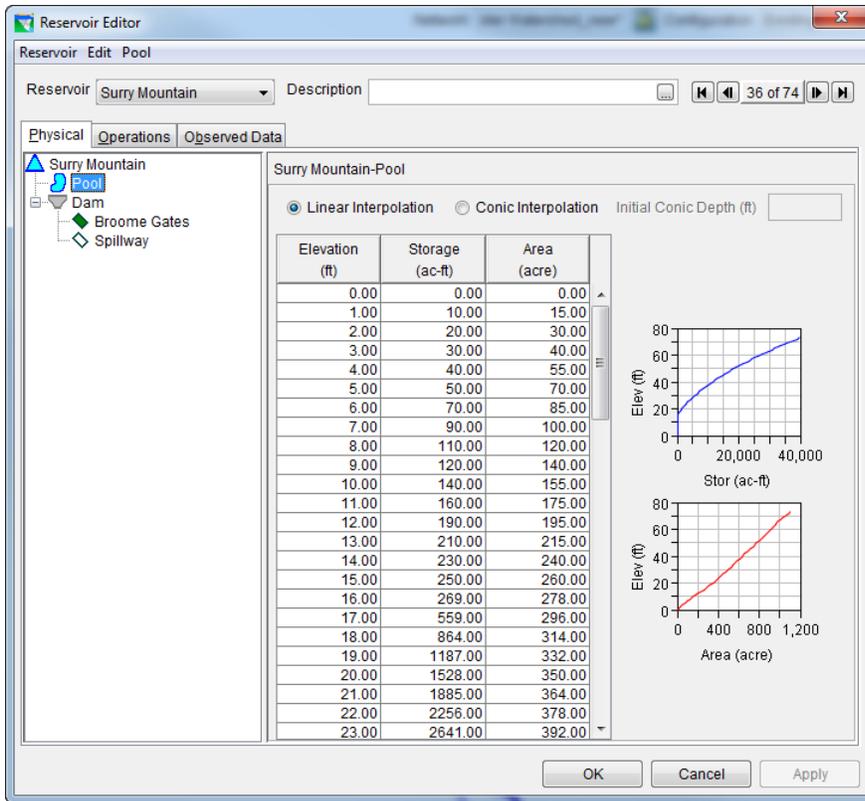


Figure 3: Reservoir Editor: Physical Tab -- Pool

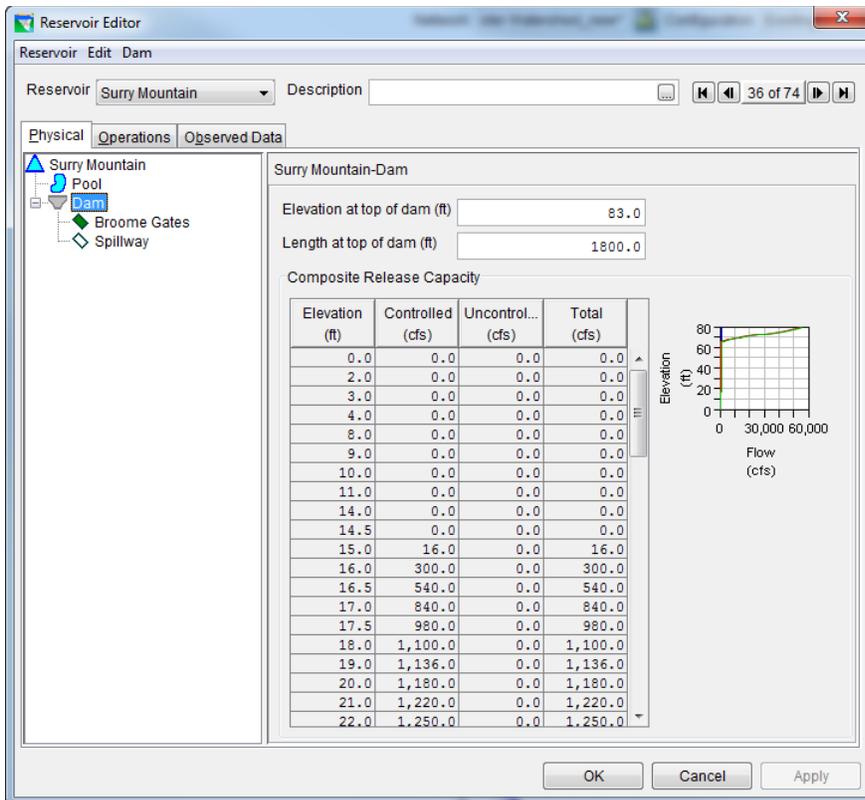


Figure 4: Reservoir Editor: Physical Tab -- Dam

### III. Operations

#### A. Operation Set

Zones are used to define the operational storage in the reservoir to determine the reservoir release through analysis of the rules contained within each zone. Figure 5 shows the definition of Surry Mountain’s “ExistingOps” operational zones, which consist of zones of Surcharge-near TOD (83 ft), Surcharge (75 ft), Flood Control (65 ft), Conservation (15-18 ft), and Inactive zone (0 ft).

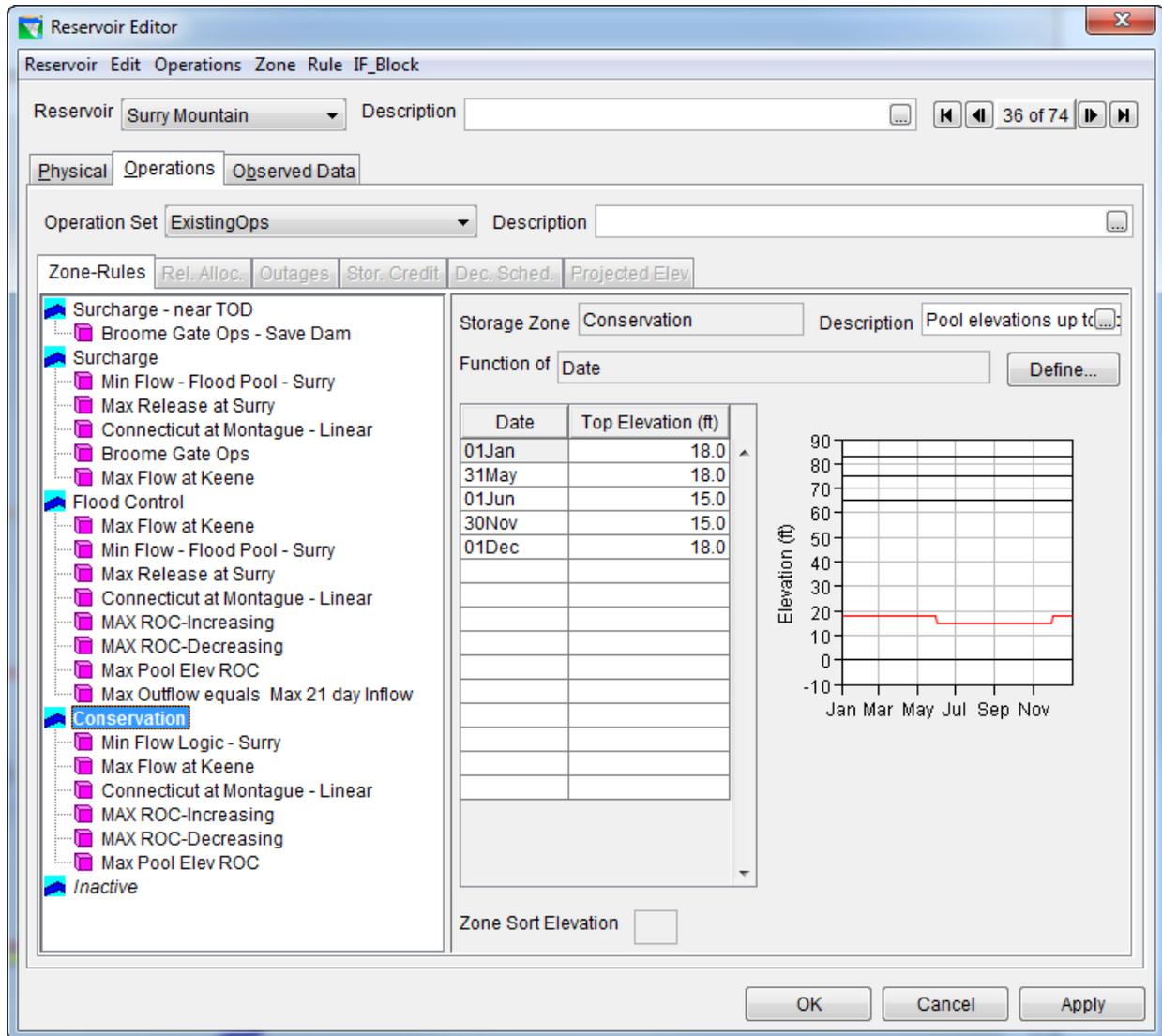


Figure 5: Reservoir Editor: Operations Tab –Existing Ops OpSet – Guide Curve

## B. Rule Illustrations

Figure 6 shows a set of operational rules specified for each zone that reflects the operation set named Existing Ops. As described in the Simulation/Verification section of the report, adjustments were made to the operations to closer match gauge data.

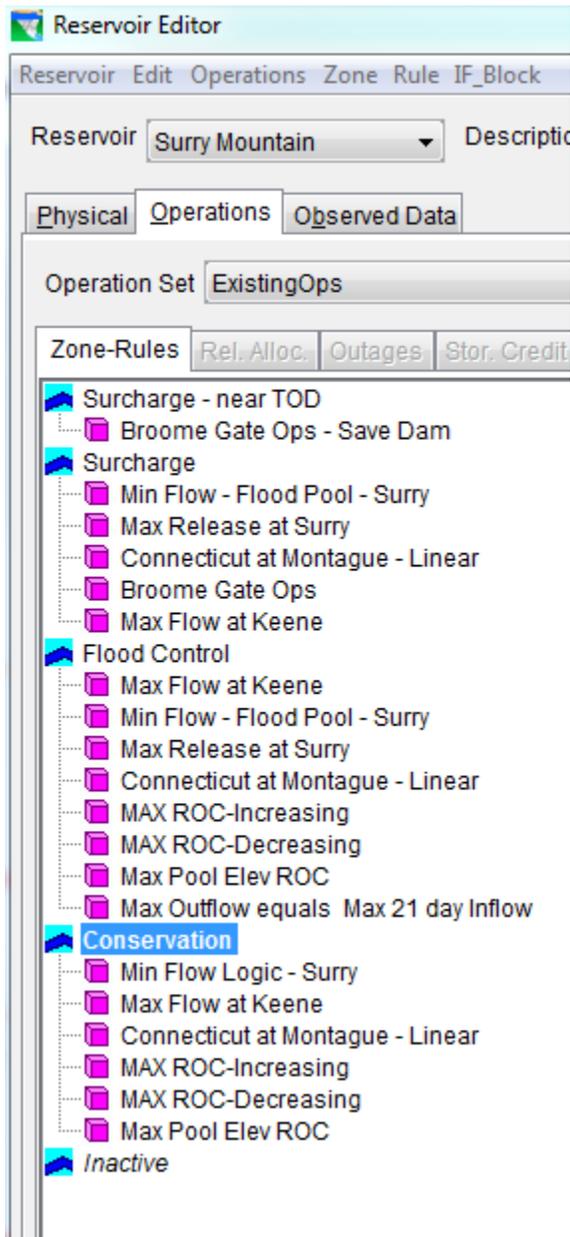


Figure 6: Reservoir Editor: Operations Tab – Existing Ops OpSet – Zones and Rules

## C. Rule Descriptions

### 1. Broome Gate Ops-Save Dam

Figure 7 shows the content of “Broome Gate Ops-Save Dam” rule. This rule represents the maximum allowable release from Slide gates as a function of pool elevation when the pool is in Surcharge-near TOD zone.

Operation Set: ExistingOps | Description: [ ]

Zone-Rules: Rel. Alloc. | Outages | Stor. Credit | Dec. Sched. | Projected Elev

Operates Release From: Surry Mountain-Broome Gates

Rule Name: Broome Gate Ops - Save Dam | Description: [ ]

Function of: Surry Mountain-Pool Elevation, Period Average, 0.0 hr lag, 48.0 hr period | Define...

Limit Type: Maxim... | Interp.: Lin...

| Elev (ft) | Release (cfs) |
|-----------|---------------|
| 75.0      | 0.0           |
| 78.0      | 800.0         |
| 80.0      | 1600.0        |
| 83.0      | 1600.0        |

Release (cfs) vs Elev (ft) Graph:

- Period Average Limit | Edit...
- Hour of Day Multiplier | Edit...
- Day of Week Multiplier | Edit...
- Rising/Falling Condition | Edit...
- Seasonal Variation | Edit...

Figure 7: Reservoir Editor: Operations Tab – Existing Ops OpSet – Broome Gate Ops-Save Dam



#### 4. Connecticut at Montague-Linear

Figure 10 shows the content of “Connecticut at Montague-Linear” rule. This rule represents the maximum allowable release from the dam as a function of the previous day stage at Montague. The previous day stage was used to account for the delay that occurs between the stage exceeding the specified target and the change in operations at the flood control dams that occurs in reality.

The screenshot displays the 'Operations Tab' in the Reservoir Editor. The 'ExistingOps' operation set is selected. The 'Zone-Rules' section is active, showing a tree view of various rules. The 'Connecticut at Montague - Linear' rule is selected and highlighted in blue. The main configuration area shows the rule name and description, the function 'Connecticut at Montague Stage, Previous Value', and the limit type 'Maxim...' with a linear interpolation. A table lists the stage and release values, and a graph plots these values. The graph shows a constant release of 1,000,000 cfs for stages up to 24.99 ft, followed by a linear decrease to 75.0 cfs at 50.0 ft.

| Stage (ft) | Release (cfs) |
|------------|---------------|
| 0.0        | 1000000.0     |
| 24.99      | 1000000.0     |
| 25.0       | 1200.0        |
| 26.0       | 960.0         |
| 27.0       | 720.0         |
| 28.0       | 480.0         |
| 29.0       | 240.0         |
| 30.0       | 75.0          |
| 50.0       | 75.0          |

Figure 10: Reservoir Editor: Operations Tab – Existing Ops OpSet – Connecticut at Montague-Linear

### 5. Broome Gate Ops

Figure 11 shows the content of “Broome Gate Ops” rule. This rule shows a seasonal maximum release from Broome gates as a function of pool elevation when the pool is in Surcharge zone.

Operation Set: ExistingOps | Description: [ ]

Zone-Rules: Rel. Alloc. | Outages | Stor. Credit | Dec. Sched. | Projected Elev.

- Surcharge - near TOD
  - Broome Gate Ops - Save Dam
- Surcharge
  - Min Flow - Flood Pool - Surry
  - Max Release at Surry
  - Connecticut at Montague - Linear
  - Broome Gate Ops**
  - Max Flow at Keene
- Flood Control
  - Max Flow at Keene
  - Min Flow - Flood Pool - Surry
  - Max Release at Surry
  - Connecticut at Montague - Linear
  - MAX ROC-Increasing
  - MAX ROC-Decreasing
  - Max Pool Elev ROC
  - Max Outflow equals Max 21 day Inflow
- Conservation
  - Min Flow Logic - Surry
  - Max Flow at Keene
  - Connecticut at Montague - Linear
  - MAX ROC-Increasing
  - MAX ROC-Decreasing
  - Max Pool Elev ROC
- Inactive

Operates Release From: Surry Mountain-Broome Gates

Rule Name: Broome Gate Ops | Description: [ ]

Function of: Surry Mountain-Pool Elevation, Period Average, 0.0 hr la | Define...

Limit Type: Maxi... | Interp.: Li...

| Elev (ft) | Release (cfs) |        |        |
|-----------|---------------|--------|--------|
|           | 01Jan         | 01May  | 01Nov  |
| 65.0      | 1250.0        | 850.0  | 1250.0 |
| 65.25     | 833.0         | 567.0  | 833.0  |
| 65.5      | 417.0         | 283.0  | 417.0  |
| 65.75     | 0.0           | 0.0    | 0.0    |
| 68.0      | 0.0           | 0.0    | 0.0    |
| 75.0      | 0.0           | 0.0    | 0.0    |
| 78.0      | 800.0         | 800.0  | 800.0  |
| 80.0      | 1600.0        | 1600.0 | 1600.0 |
| 83.0      | 1600.0        | 1600.0 | 1600.0 |

Period Average Limit | Edit...  
 Hour of Day Multiplier | Edit...  
 Day of Week Multiplier | Edit...  
 Rising/Falling Condition | Edit...  
 Seasonal Variation | Edit...

Figure 11: Reservoir Editor: Operations Tab – Existing Ops OpSet – Broome Gate Ops

### 6. Max Flow at Keene

Figure 12 shows the content of “Max Flow at Keene” rule. This rule represents the maximum allowable flow downstream at the point Ashuelot+Otter Brook.

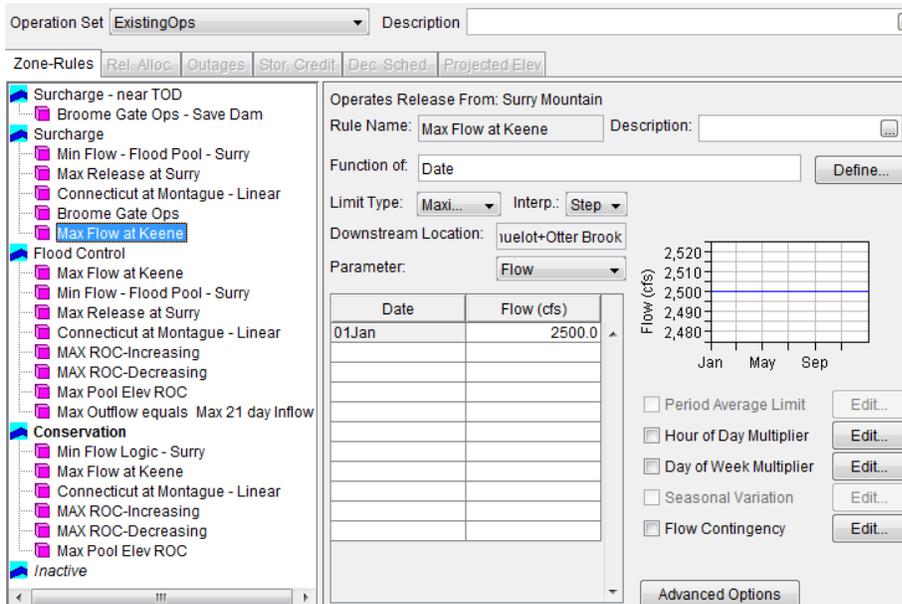


Figure 12: Reservoir Editor: Operations Tab – Existing Ops OpSet – Max Flow at Keene

### 7. Max ROC-Increasing

Figure 13 shows the content of “Max ROC-Increasing” rule. This rule shows the maximum allowable increasing release rate of change as a function of release from Surry Mountain dam.

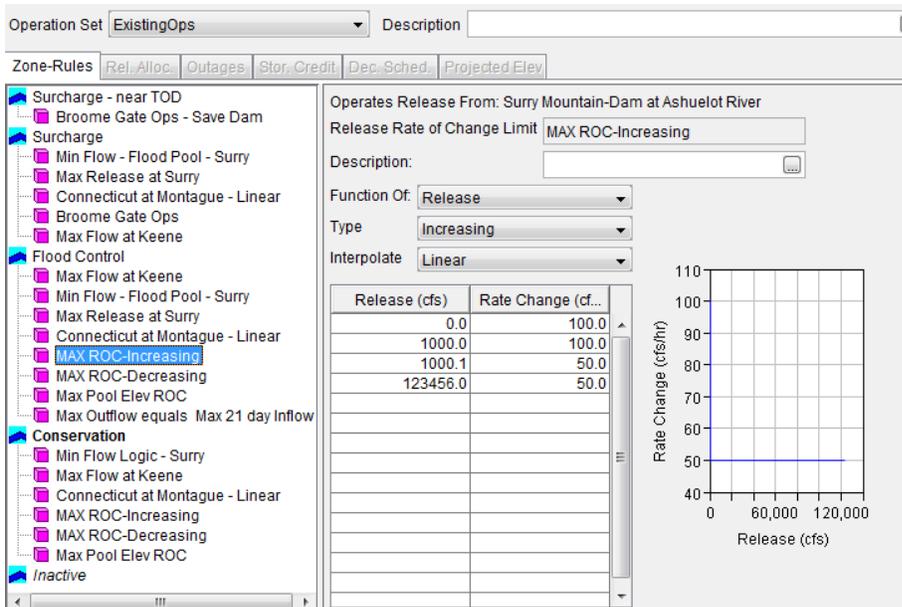


Figure 13: Reservoir Editor: Operations Tab – Existing Ops OpSet – Max ROC-Increasing

### 8. Max ROC-decreasing

Figure 14 shows the content of “Max ROC-Decreasing” rule. This rule shows the maximum allowable decreasing release rate of change as a function of release from Surry Mountain dam.

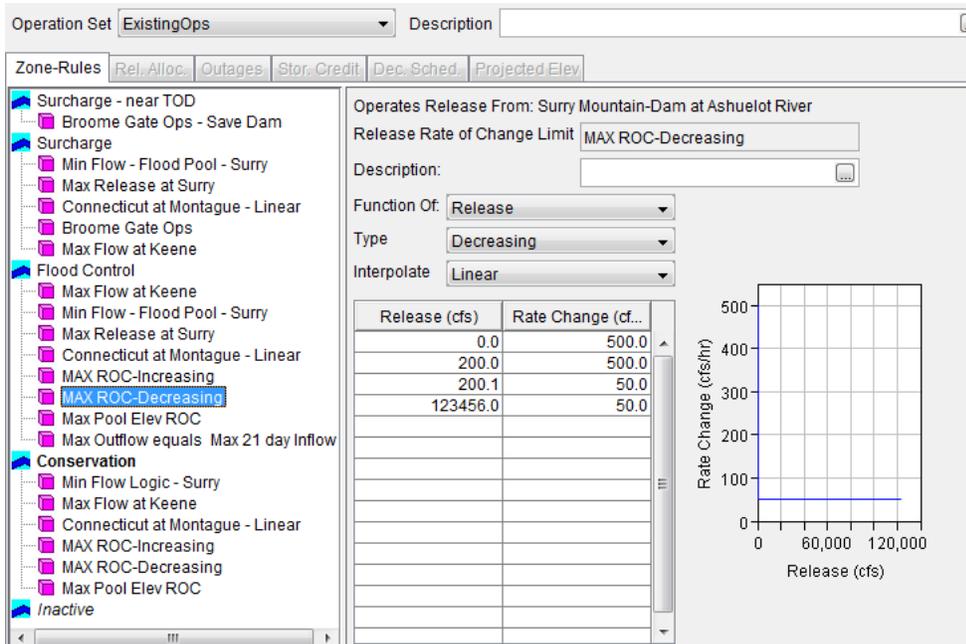


Figure 14: Reservoir Editor: Operations Tab – Existing Ops OpSet – Max ROC-Decreasing

### 9. Max Pool Elev ROC

Figure 15 shows the content of “Max pool Elev ROC” rule. This rule shows the maximum allowable decreasing pool elevation rate of change.

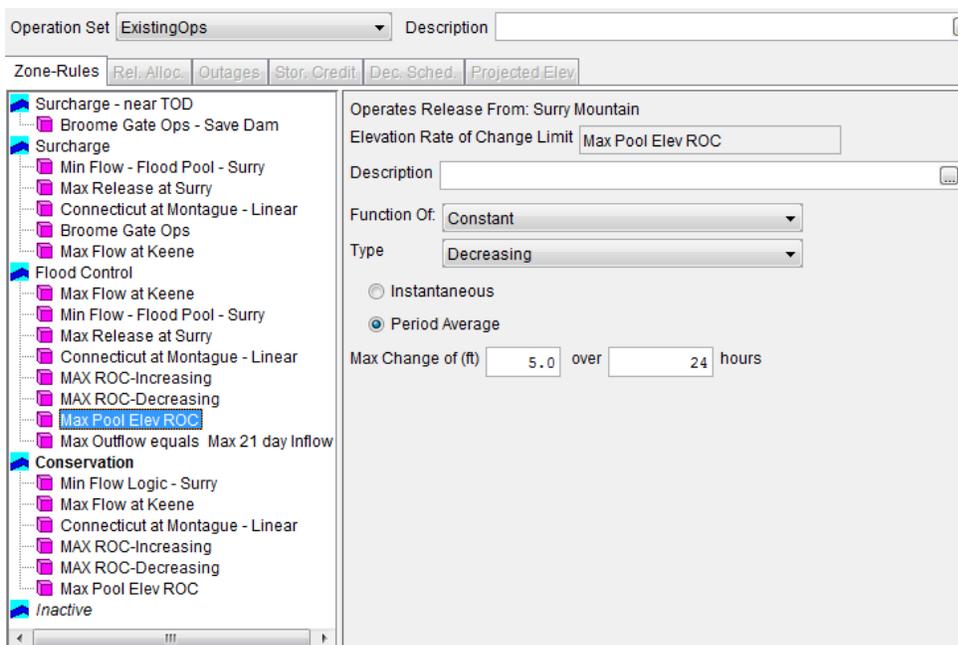


Figure 15: Reservoir Editor: Operations Tab – Existing Ops OpSet – Max Pool Elev ROC

### 10. Max Outflow equals Max 21 day Inflow

Figure 16 shows the content of “Max Outflow equals Max 21 day Inflow” rule. This rule represents the maximum release from dam as a function of the previous 3 weeks of inflow.

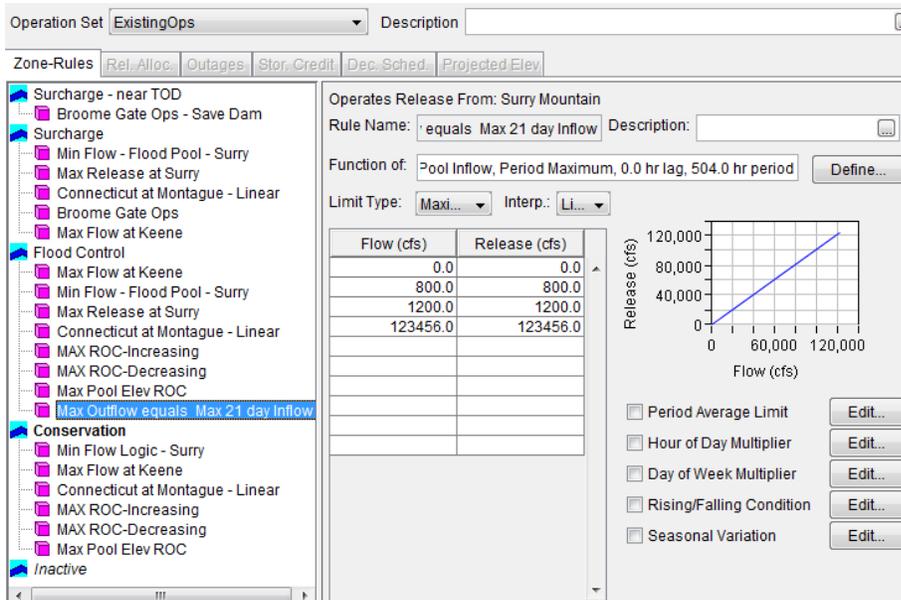


Figure 16: Reservoir Editor: Operations Tab – Existing Ops OpSet – Max Outflow equals Max 21 day Inflow

### 11. Min Flow Logic-Surry

Figure 17 shows the content of “Min flow Logic-Surry” rule. This rule provides seasonal minimum releases from Surry Mountain as a function of inflow.

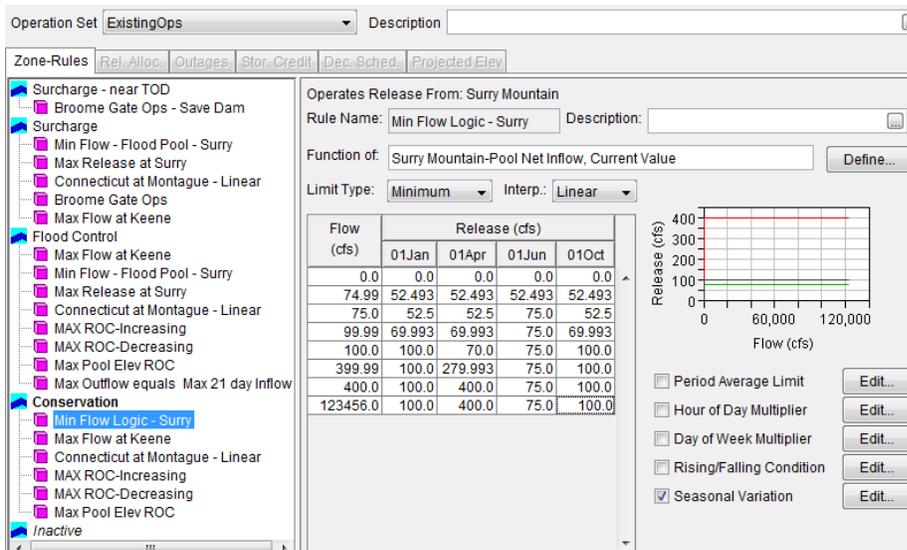


Figure 17: Reservoir Editor: Operations Tab – Existing Ops OpSet – Min Flow Logic -Surry

# Tighe Carmody

## I. Overview

Tighe Carmody dam is located in the town of Southamptom, MA on the Manhan River. It is owned and operated by Holyoke Water Works and is used for water supply for the City of Holyoke.

Figure 1 shows the location of Tighe Carmody Dam as it is represented in the HEC-ResSim model. Figure 2 shows a photo of Tighe Carmody dam.

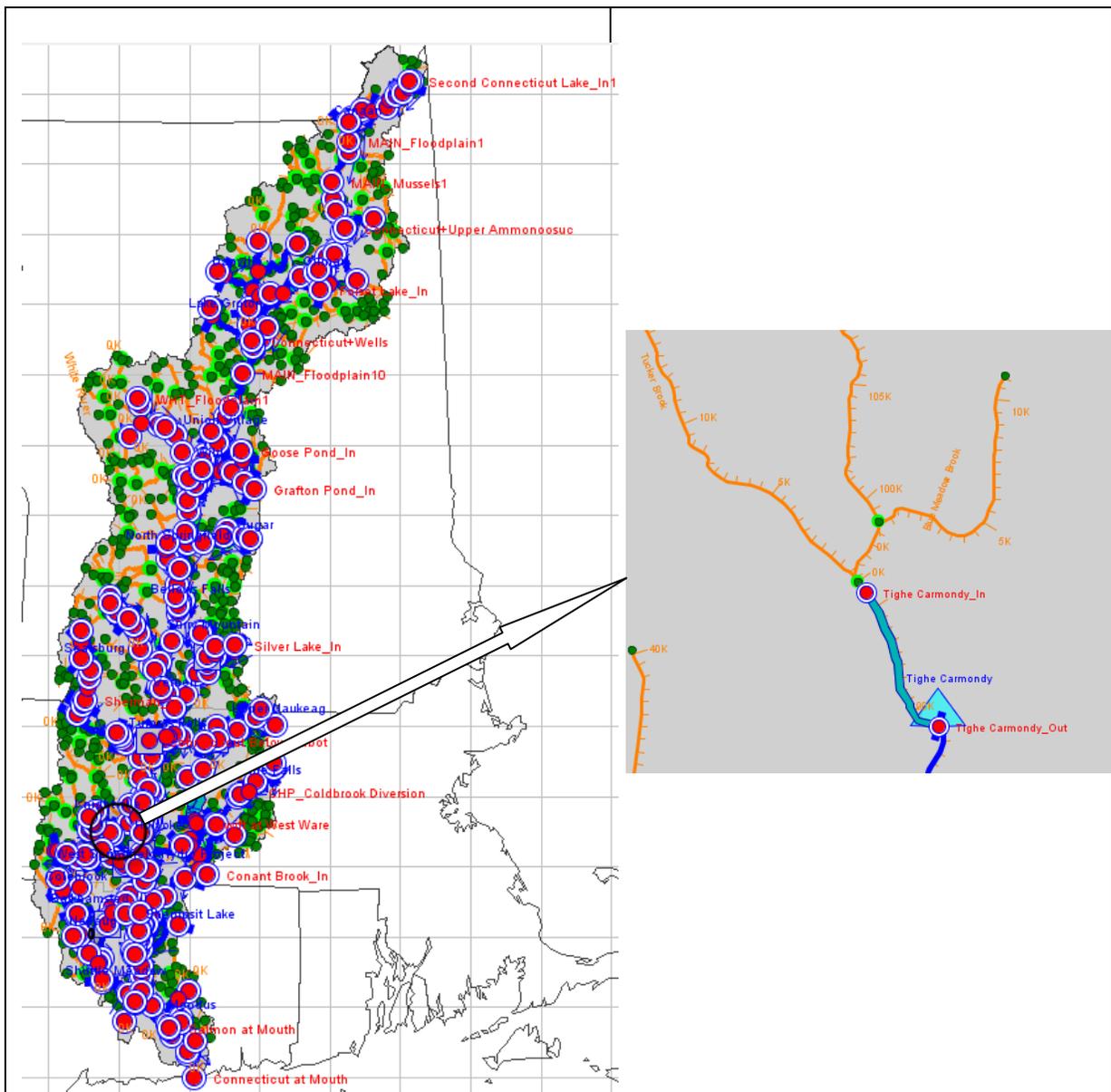


Figure 1: HEC-ResSim Map Display Showing Location of Tighe Carmody



**Figure 2: HEC-ResSim Photo of Tighe Carmody Dam**

## **II. Physical Characteristics**

The physical characteristics of the reservoir are separated between the Pool and the Dam in the HEC-ResSim model. The elevation-storage-area defines the pool as shown in Figure 3<sup>96</sup>. The dam consists of two types of outlets: (1) uncontrolled spillway, and (2) controlled Draw-down Conduit as shown in Figure 4.

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<sup>96</sup> Phase I Report. 1978



### III. Operations

#### A. Operation Set

Zones are used to define the operational storage in the reservoir to determine the reservoir release through analysis of the rules contained within each zone. Figure 5 shows the definition of Tighe Carmondy’s “Existing Ops” operational zones, which consist of zones of Flood Control (495.5 ft), conservation (481 ft), and Inactive zone (365 ft)<sup>1</sup>.

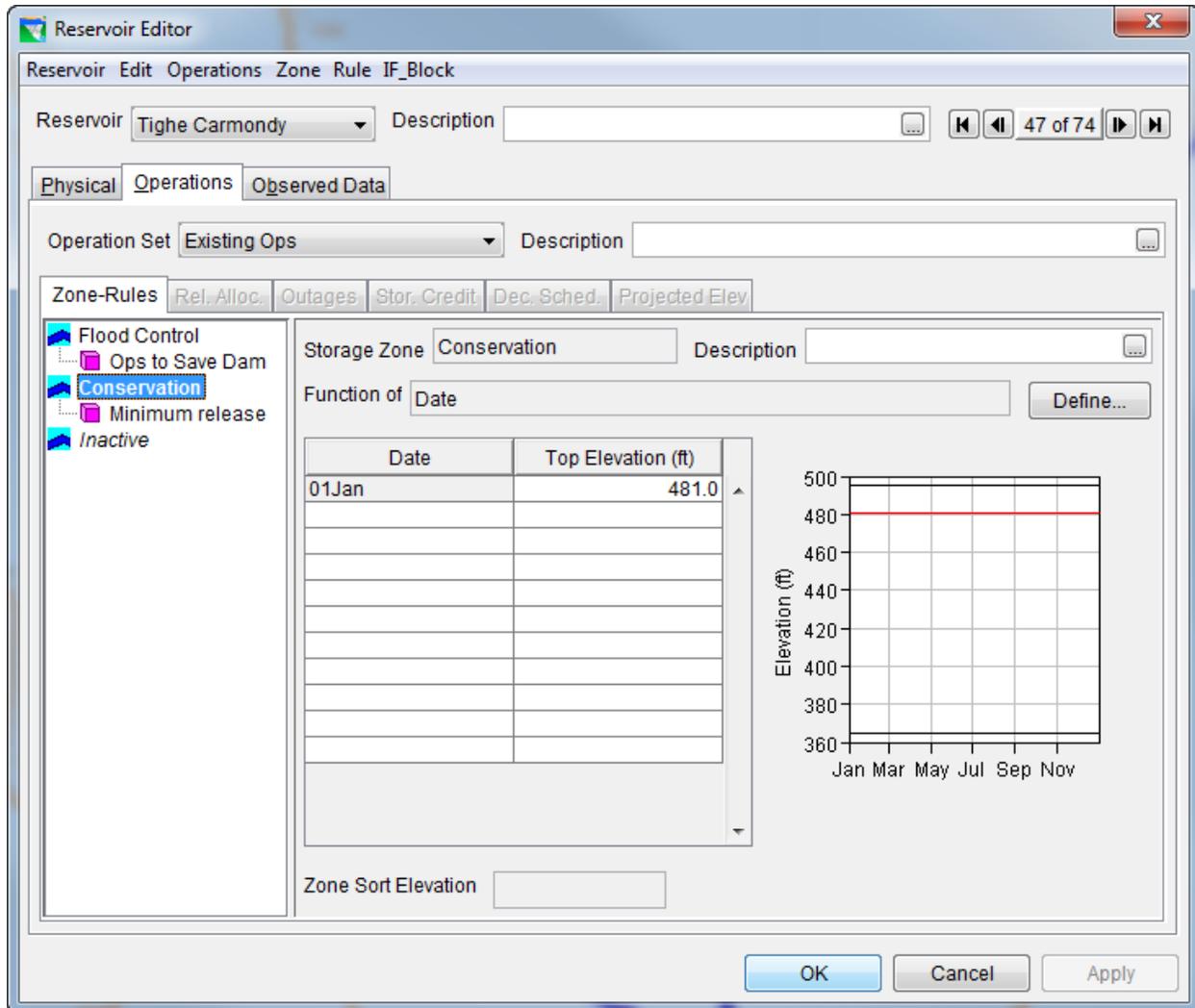


Figure 5: Reservoir Editor: Operations Tab –Existing Ops OpSet – Guide Curve

## B. Rule Illustrations

Figure 5 shows a set of operational rules specified for each zone that reflects the operation set named Existing Ops. There is a water supply time series associated with Tighe Carmondy which is described in the water supply section of the report.

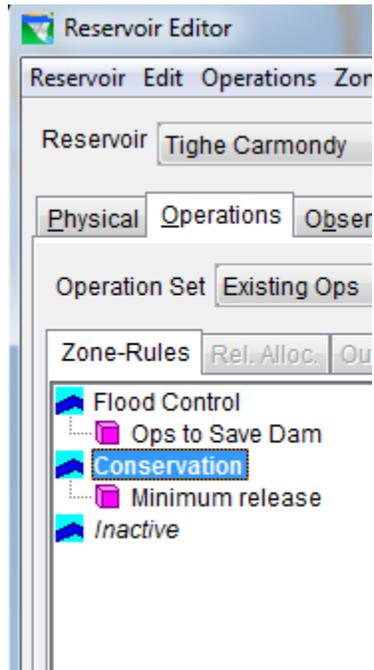


Figure 6: Reservoir Editor: Operations Tab – Existing Ops OpSet – Zones and Rules

## C. Rule Descriptions

### 1. Ops to save Dam

Figure 7 shows the content of “Ops to save Dam” rule. This rule shows when the pool elevation gets to elevation 487 ft the maximum release of 1940 will occur to save the dam.

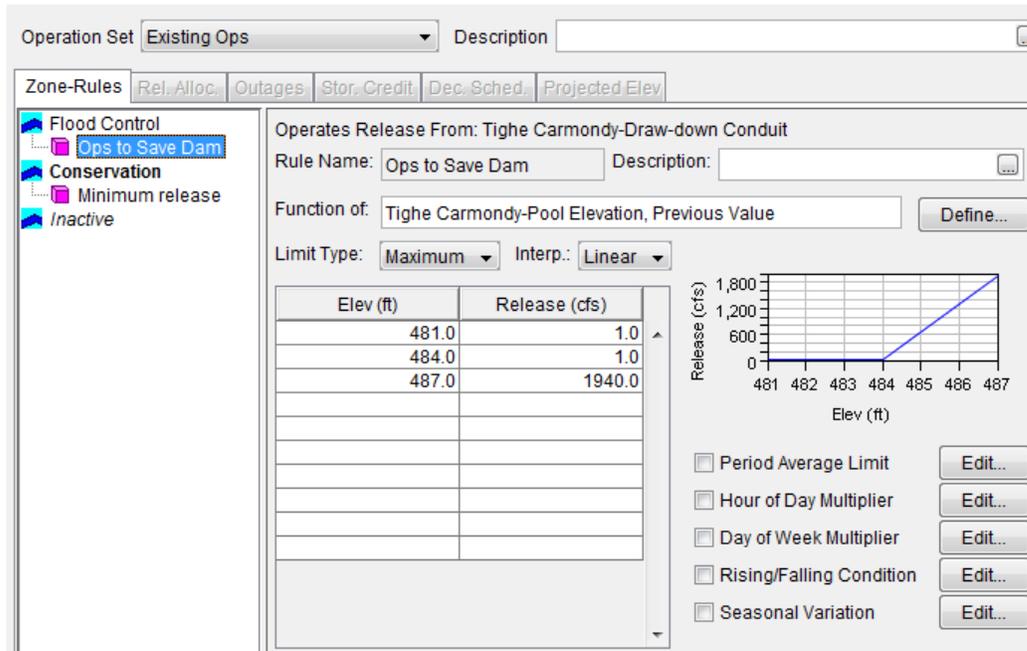


Figure 7: Reservoir Editor: Operations Tab – Existing Ops OpSet – Ops to save Dam

## 2. Minimum Release

Figure 8 shows the content of “Minimum Release” rule. This rule represents a minimum release of 1 cfs from Tighe Carmondy reservoir.

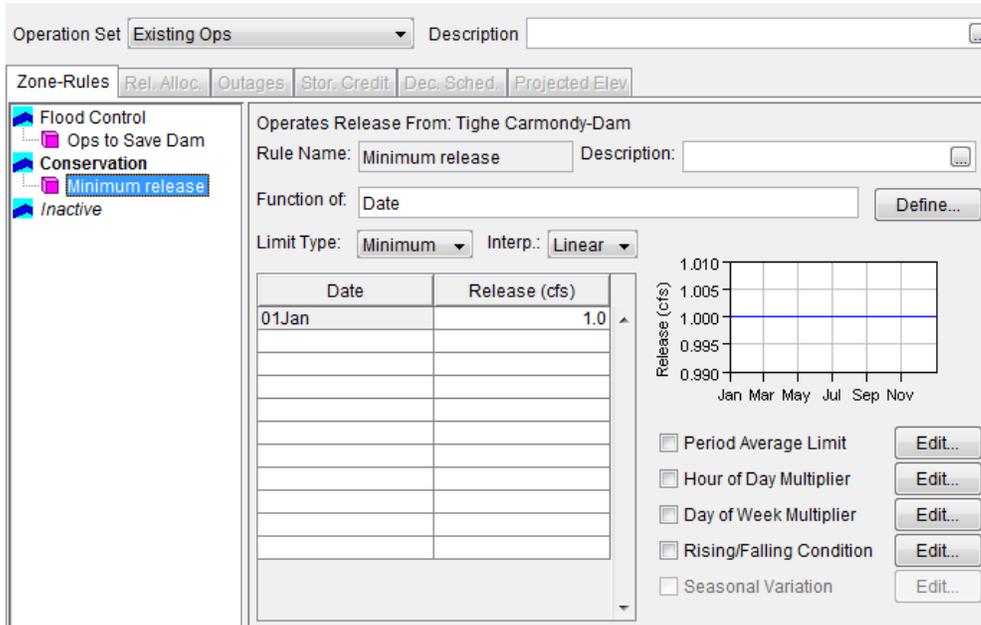


Figure 8: Reservoir Editor: Operations Tab – Existing Ops OpSet – Minimum Release





Figure 2: Photo of Townshend dam

## II. Physical Characteristics

The physical characteristics of the reservoir are separated between the Pool and the Dam in the HEC-ResSim model. The elevation-storage-area defines the pool as shown in Figure 3. The dam consists of two types of outlets: (1) controlled vertical lift gates, and (2) uncontrolled spillway, as shown in Figure 4. All physical and operations data were provided by US Army Corps New England District, through both a previously created ResSim model and the Reservoir Regulation Team website<sup>97</sup>.

<sup>97</sup> [http://rsgisias.crrel.usace.army.mil/nae/cwms\\_map.map\\_index](http://rsgisias.crrel.usace.army.mil/nae/cwms_map.map_index)

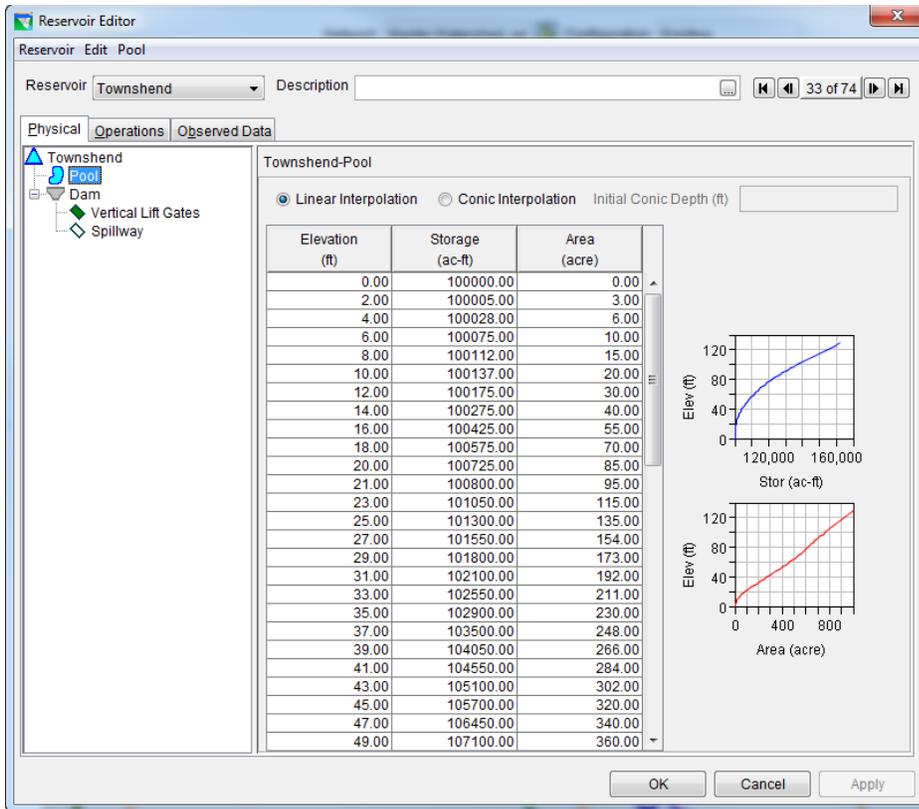


Figure 3: Reservoir Editor: Physical Tab -- Pool

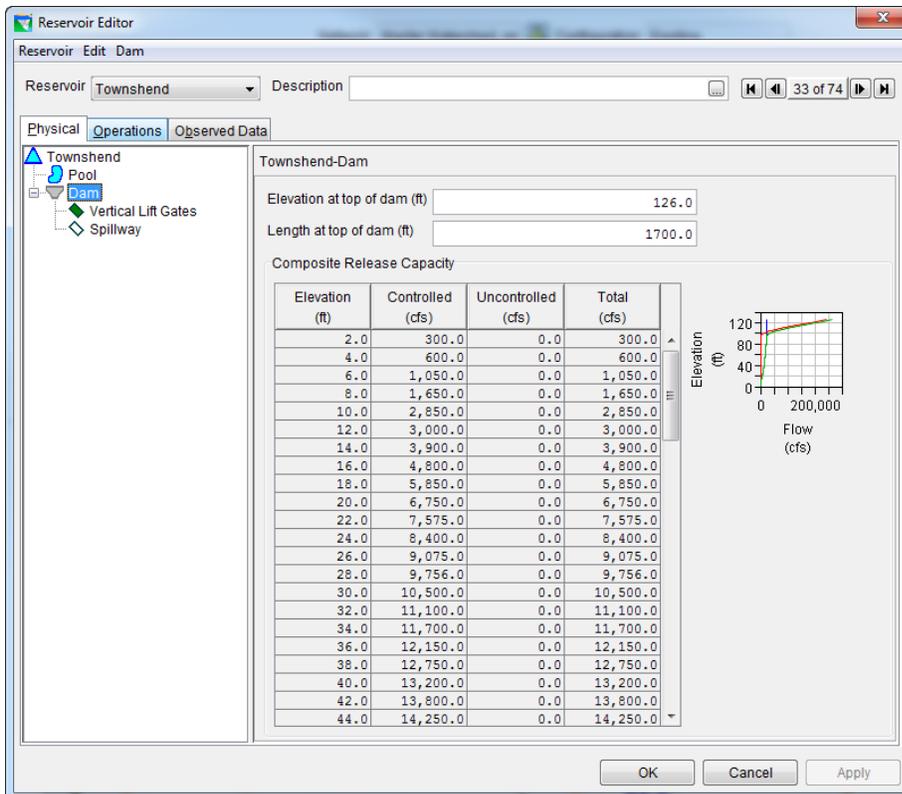


Figure 4: Reservoir Editor: Physical Tab -- Dam



## B. Rule Illustrations

Figure 6 shows a set of operational rules specified for each zone that reflects the operation set named Existing Ops. As described in the Simulation/Verification section of the report, adjustments were made to the operations to closer match gauge data.

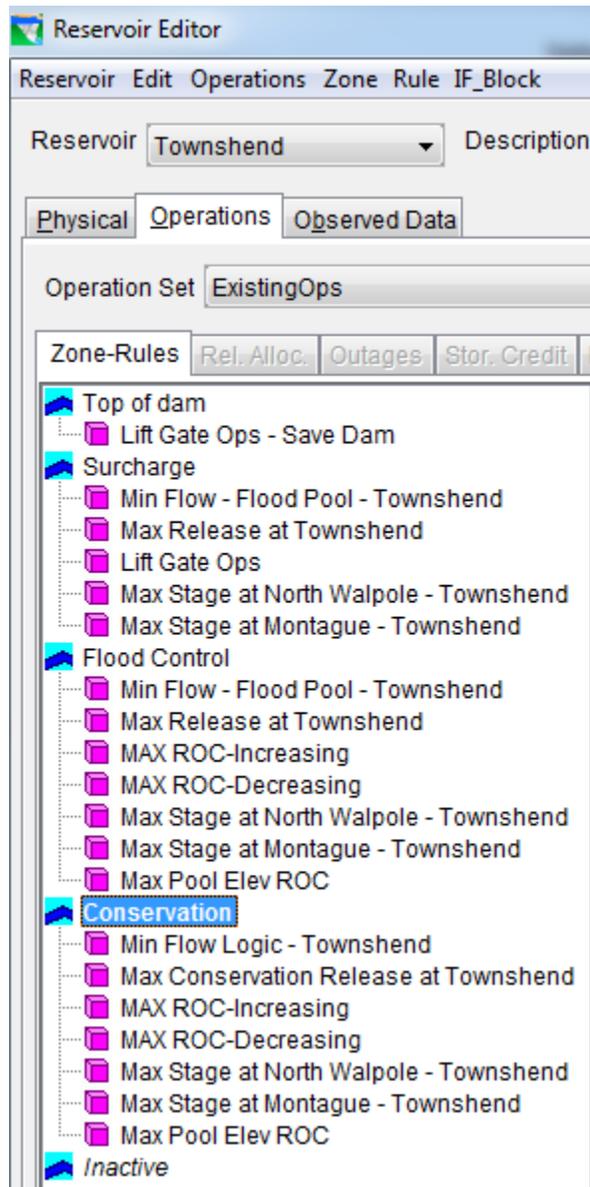


Figure 6: Reservoir Editor: Operations Tab – Existing Ops OpSet – Zones and Rules

## C. Rule Descriptions

### 1. Lift Gate Ops-Save Dam

Figure 7 shows the content of “Lift Gate Ops-Save Dam” rule. This rule represents the maximum allowable release from Lift gates when the pool is in Top of dam zone as a function of pool elevation.

The screenshot displays the 'Operations Tab' for the 'ExistingOps' set. The selected rule is 'Lift Gate Ops - Save Dam'. The configuration panel shows the following details:

- Operates Release From:** Townshend-Vertical Lift Gates
- Rule Name:** Lift Gate Ops - Save Dam
- Function of:** end-Pool Elevation, Period Average, 0.0 hr lag, 48.0 hr period
- Limit Type:** Maximum
- Interp.:** Line

| Elev (ft) | Release (cfs) |
|-----------|---------------|
| 116.0     | 0.0           |
| 118.0     | 5000.0        |
| 120.0     | 24300.0       |
| 126.0     | 24300.0       |

The graph on the right plots Release (cfs) against Elev (ft), showing a curve that rises from 0 cfs at 116 ft to 24,300 cfs at 120 ft, and then remains constant at 24,300 cfs up to 126 ft.

Additional options on the right include checkboxes for 'Period Average Limit', 'Hour of Day Multiplier', 'Day of Week Multiplier', 'Rising/Falling Condition', and 'Seasonal Variation', each with an 'Edit...' button.

Figure 7: Reservoir Editor: Operations Tab – Existing Ops OpSet – Lift Gate Ops-Save Dam

### 2. Min Flow-Flood Pool-Townshend

Figure 8 shows the content of “Min Flow-Flood pool-Townshend” rule. This rule represents the minimum required release from dam during flood control operations.

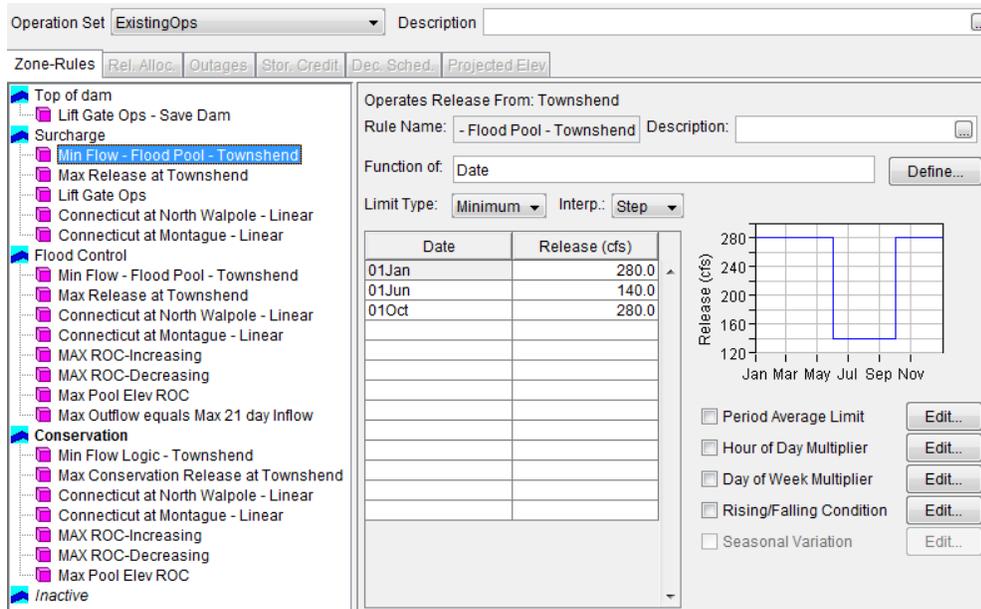


Figure 8: Reservoir Editor: Operations Tab – Existing Ops OpSet – Min Flow-Flood pool-Townshend

### 3. Max Release at Townshend

Figure 9 shows the content of “Max release at Townshend” rule. This rule assigns 9000 cfs as a maximum release from dam.

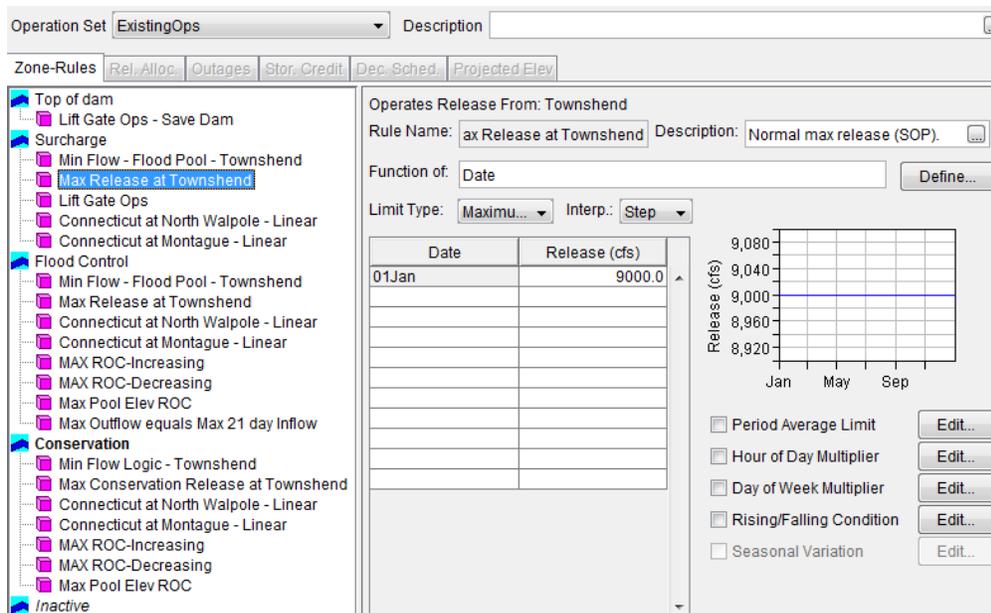


Figure 9 Reservoir Editor: Operations Tab – Existing Ops OpSet – Max Release at Townshend

#### 4. Lift Gate Ops

Figure 10 shows the content of “Lift Gate Ops” rule. This rule represents the maximum allowable release from Lift gates as a function of pool elevation when pool is in surcharge zone.

Operation Set: ExistingOps | Description: [ ]

Zone-Rules: Rel. Alloc. | Outages | Stor. Credit | Dec. Sched. | Projected Elev

Operates Release From: Townshend-Vertical Lift Gates

Rule Name: Lift Gate Ops | Description: [ ]

Function of: end-Pool Elevation, Period Average, 0.0 hr lag, 48.0 hr period [ Define... ]

Limit Type: Maximum... | Interp.: Line...

| Elev (ft) | Release (cfs) |
|-----------|---------------|
| 96.0      | 9000.0        |
| 97.0      | 6500.0        |
| 98.0      | 4000.0        |
| 99.0      | 1000.0        |
| 99.22     | 0.0           |
| 116.0     | 0.0           |
| 118.0     | 5000.0        |
| 120.0     | 24300.0       |
| 126.0     | 24300.0       |

Graph: Release (cfs) vs. Elev (ft)

Options:

- Period Average Limit [ Edit... ]
- Hour of Day Multiplier [ Edit... ]
- Day of Week Multiplier [ Edit... ]
- Rising/Falling Condition [ Edit... ]
- Seasonal Variation [ Edit... ]

Figure 10: Reservoir Editor: Operations Tab – Existing Ops OpSet – Lift Gate Ops

### 5. Connecticut at North Walpole-Linear

Figure 11 shows the content of “Connecticut at North Walpole-Linear” rule. This rule represents the maximum allowable release from dam as a function of previous day stage at North Walpole. The SOP for Townshend was slightly different than the other flood control dams in that it called for an immediate reduction to 3000 cfs when a mainstem stage target was exceeded. Then the SOP says that the outflow will be directed by the Reservoir Regulation Team. The immediate reduction to 3000 cfs was accounted for in the rule and then 3000 cfs was used as the maximum when applying the linear release cutback described in the Simulation/Verification section of the report. The previous day stage was used to account for the delay that occurs between the stage exceeding the specified target and the change in operations at the flood control dams that occurs in reality.

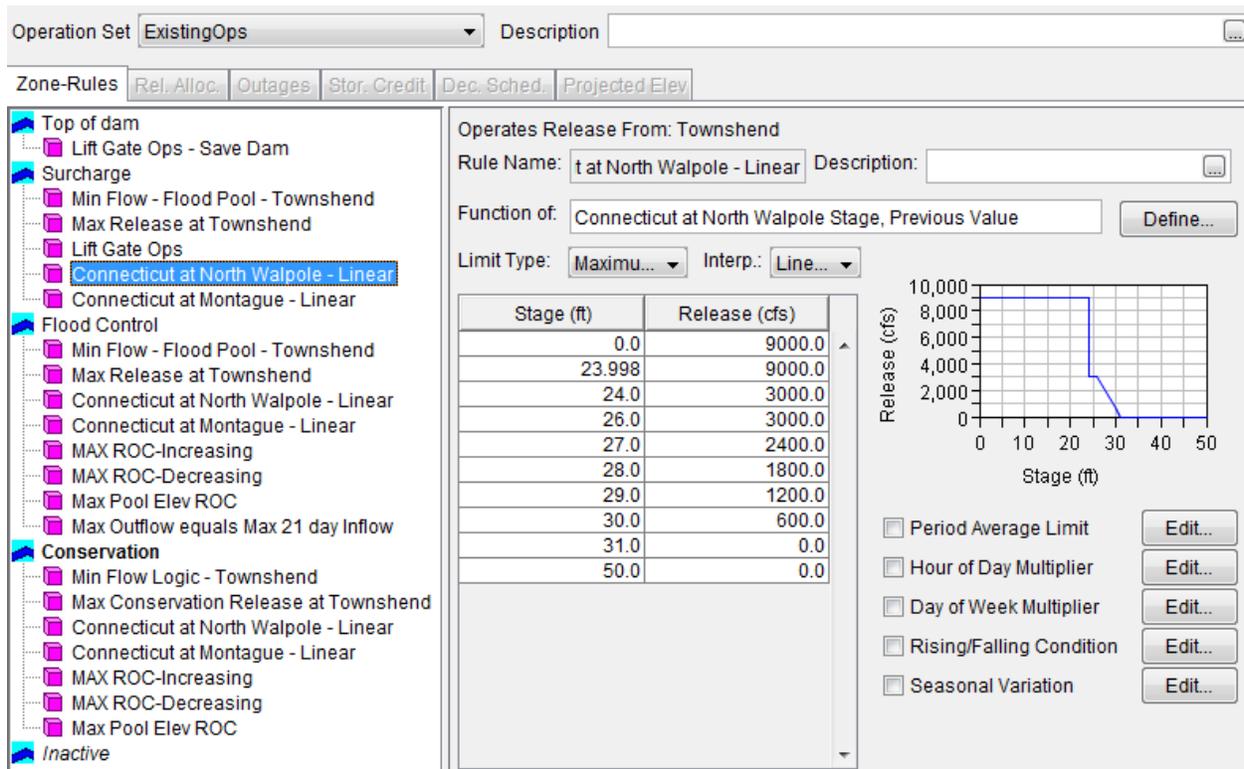


Figure 11: Reservoir Editor: Operations Tab – Existing Ops OpSet – Connecticut at North Walpole-Linear

### 6. Connecticut at Montague-Linear

Figure 12 shows the content of “Connecticut at Montague-Linear” rule. This rule represents the maximum allowable release from dam as a function of previous day stage at Montague. The SOP for Townshend was slightly different than the other flood control dams in that it called for an immediate reduction to 3000 cfs when a mainstem stage target was exceeded. Then the SOP says that the outflow will be directed by the Reservoir Regulation Team. The immediate reduction to 3000 cfs was accounted for in the rule and then 3000 cfs was used as the maximum when applying the linear release cutback described in the Simulation/Verification section of the report. The previous day stage was used to account for the delay that occurs between the stage exceeding the specified target and the change in operations at the flood control dams that occurs in reality.

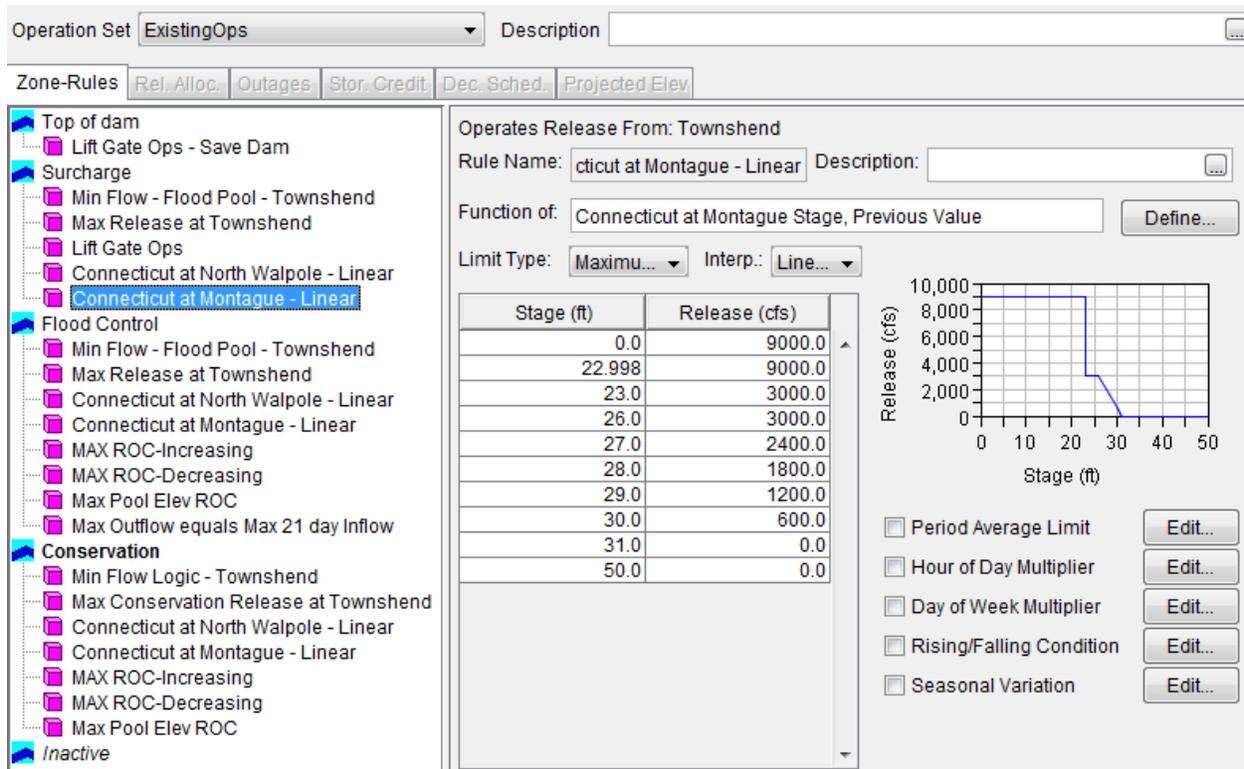


Figure 12: Reservoir Editor: Operations Tab – Existing Ops OpSet – Connecticut at Montague-Linear

### 7. MAX ROC-Increasing

Figure 13 shows the content of “MAX ROC-Increasing” rule. This rule shows the maximum allowable increasing release rate of change as a function of release from Townshend dam.

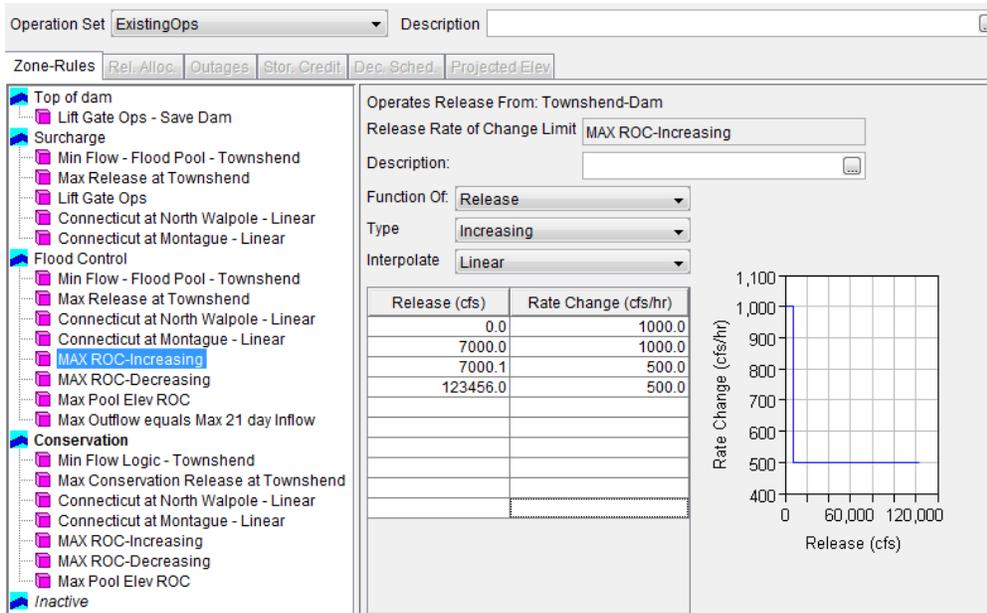


Figure 13: Reservoir Editor: Operations Tab – Existing Ops OpSet – MAX ROC-Increasing

### 8. MAX ROC-Decreasing

Figure 14 shows the content of “MAX ROC-Decreasing” rule. This rule shows the maximum allowable decreasing release rate of change from Townshend dam.

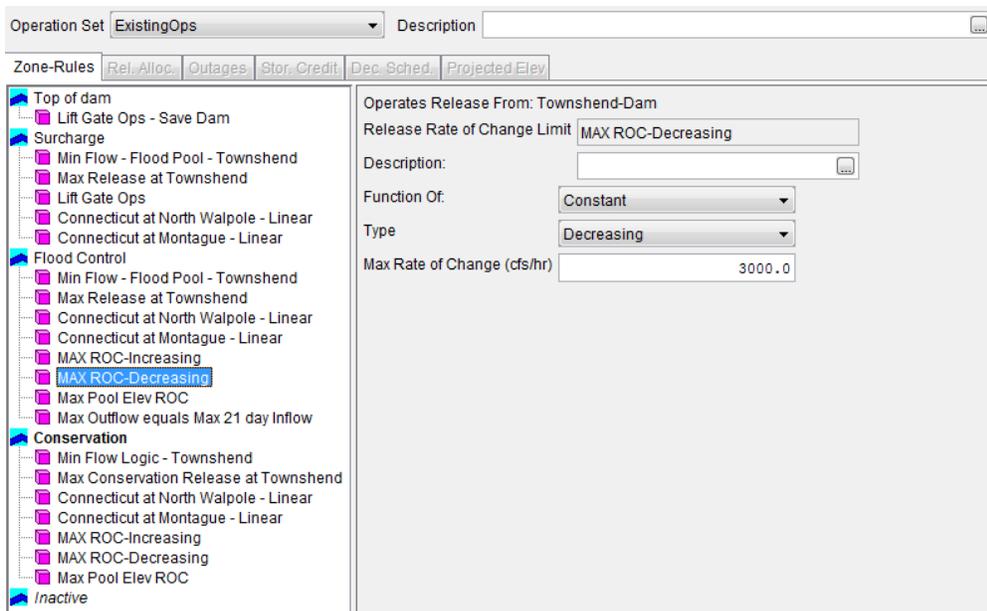


Figure 14: Reservoir Editor: Operations Tab – Existing Ops OpSet – MAX ROC-Decreasing

### 9. Max Pool Elev ROC

Figure 15 shows the content of “Max Pool Elev ROC” rule. This rule shows the maximum allowable decreasing pool elevation rate of change.

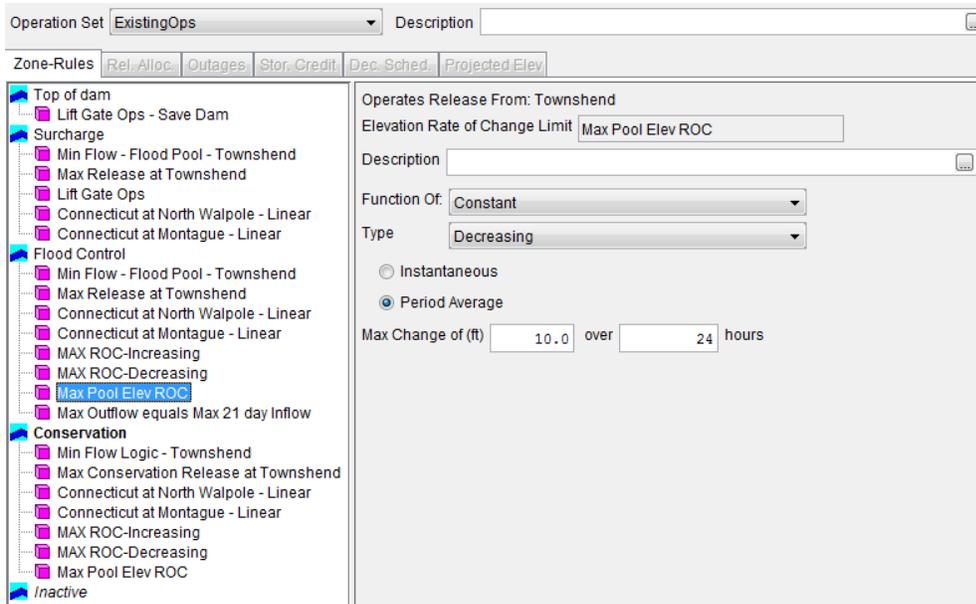


Figure 15: Reservoir Editor: Operations Tab – Existing Ops OpSet – Max Pool Elev ROC

### 10. Max Outflow equals Max 21 day Inflow

Figure 16 shows the content of “Max Outflow equals Max 21 day Inflow” rule. This rule represents the maximum release from dam as a function of Inflow.

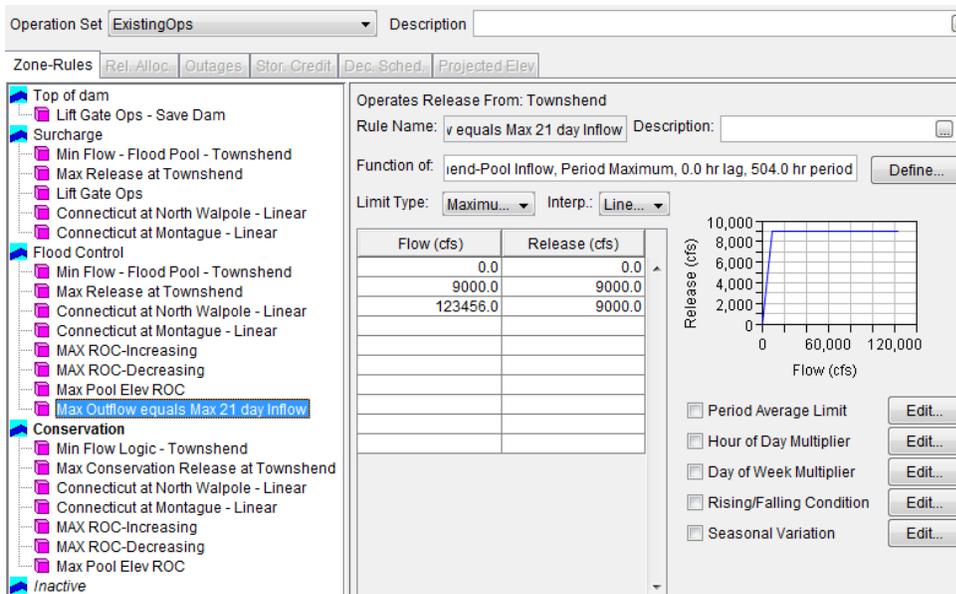


Figure 16: Reservoir Editor: Operations Tab – Existing Ops OpSet – Max Outflow equals Max 21 day Inflow



# Tully

## I. Overview

Tully Lake dam is a dam located in Royalston, Massachusetts on the Millers River. It was constructed in 1949 by the US Army Corps of Engineers and is still owned and operated by the Corps. It is primarily used for flood control purposes but also for recreation.

Figure 1 shows the location of Tully Dam as it is represented in the HEC-ResSim model, and Figure 2 shows the photo from Tully dam.

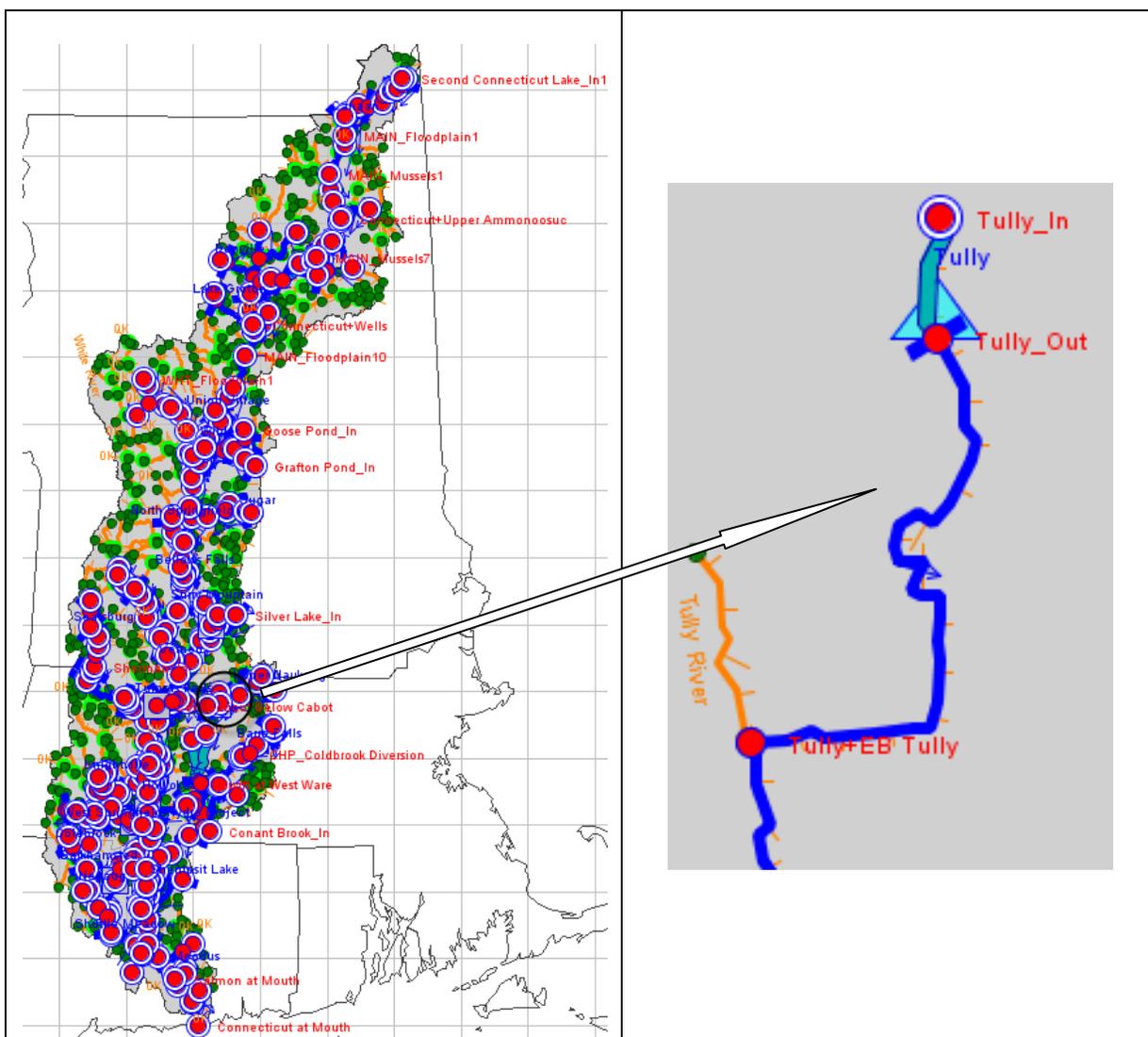


Figure 1: HEC-ResSim Map Display Showing Location of Tully dam



Figure 2: Photo of Tully Lake dam.

## II. Physical Characteristics

The physical characteristics of the reservoir are separated between the Pool and the Dam in the HEC-ResSim model. The elevation-storage-area defines the pool as shown in Figure 3. The dam consists of two types of outlets: (1) controlled slide gates, and (2) uncontrolled spillway, as shown in Figure 4. All physical and operations data were provided by US Army Corps New England District, through both a previously created ResSim model and the Reservoir Regulation Team website<sup>98</sup>.

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<sup>98</sup> [http://rsgisias.crrel.usace.army.mil/nae/cwms\\_map.map\\_index](http://rsgisias.crrel.usace.army.mil/nae/cwms_map.map_index)

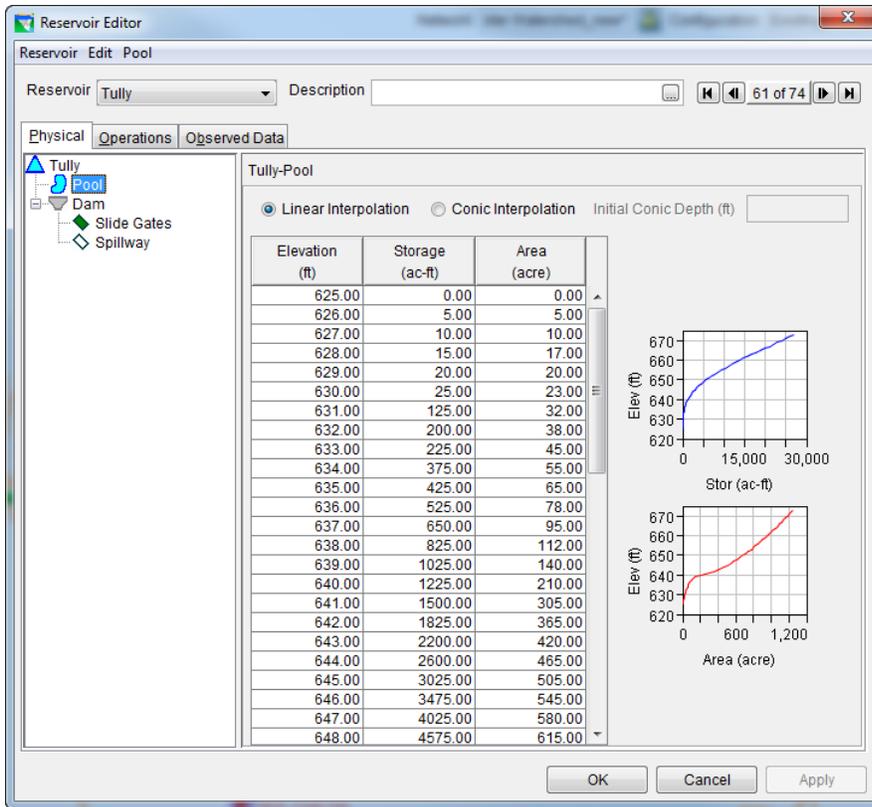


Figure 3: Reservoir Editor: Physical Tab -- Pool

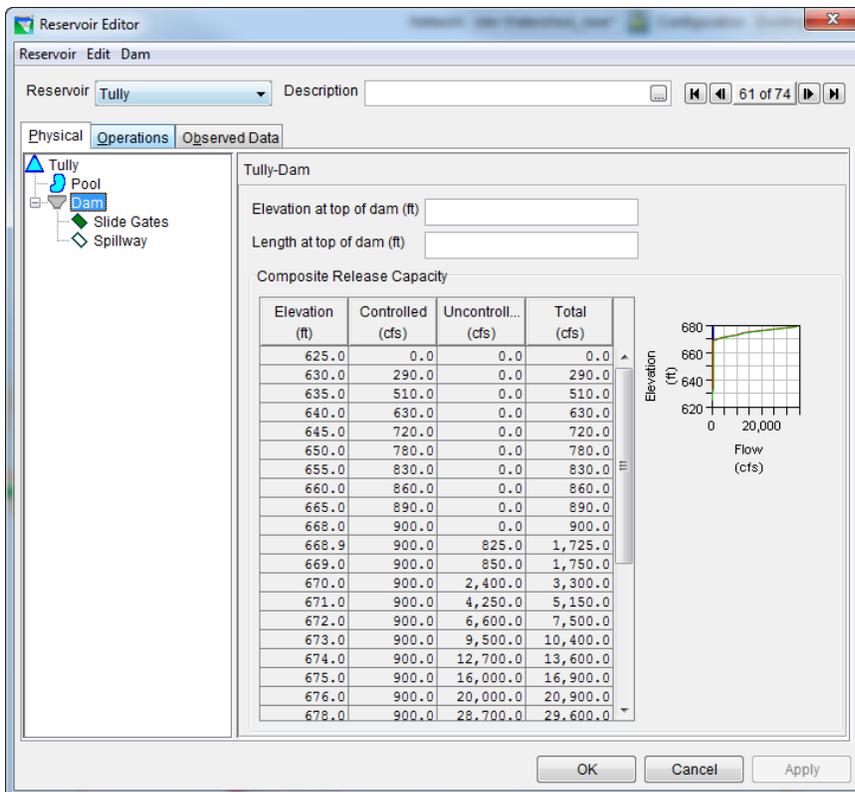


Figure 4: Reservoir Editor: Physical Tab -- Dam

### III. Operations

#### A. Operation Set

Zones are used to define the operational storage in the reservoir to determine the reservoir release through analysis of the rules contained within each zone. Figure 5 shows the definition of Tully’s “ExistingOps” operational zones, which consist of zones of Excess Surcharge (684 ft), Surcharge Storage (672 ft), Flood Control (668 ft), Conservation (638-641 ft), and Inactive zone (625 ft).

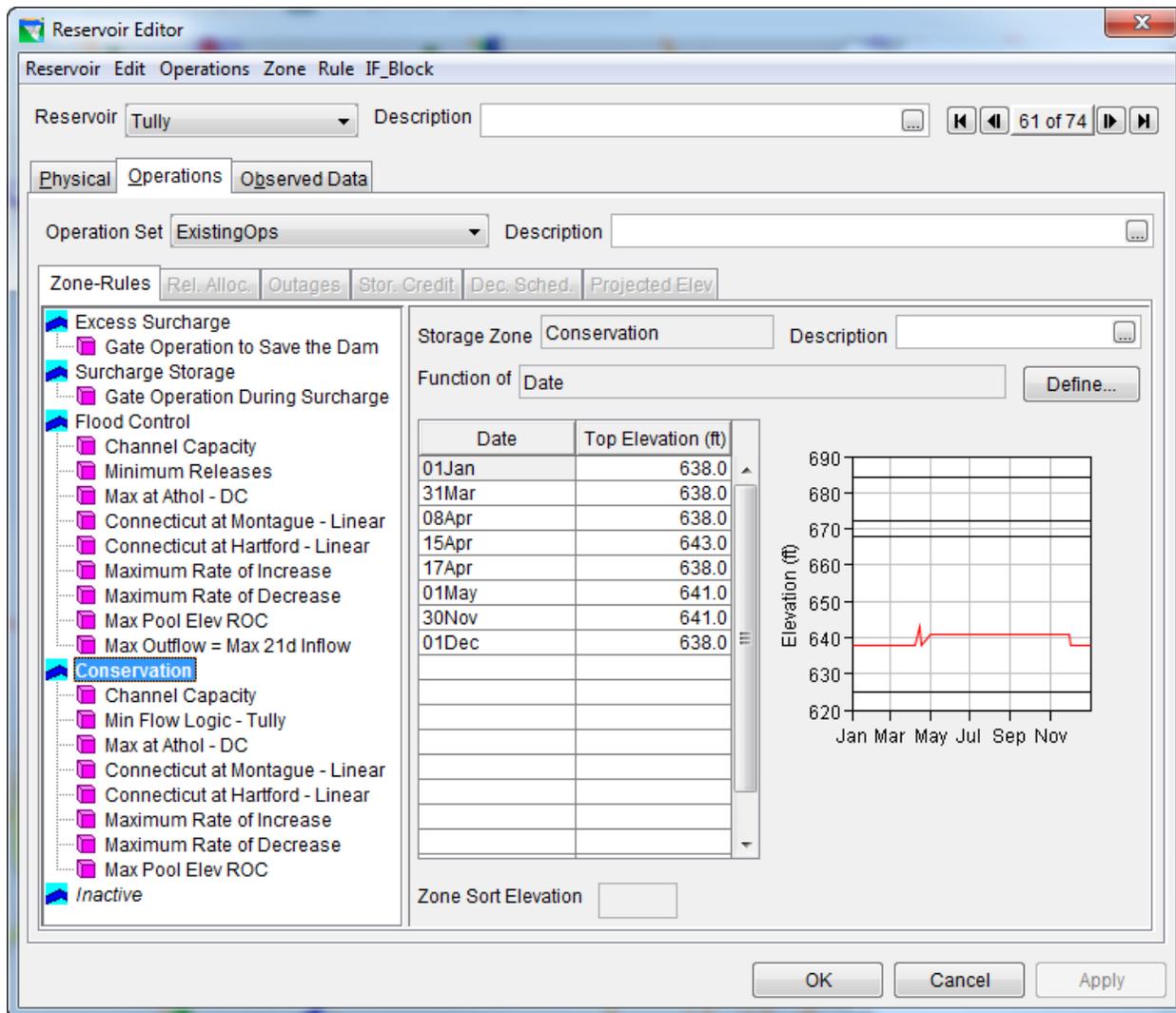


Figure 5: Reservoir Editor: Operations Tab –Existing Ops OpSet – Guide Curve

## B. Rule Illustrations

Figure 6 shows a set of operational rules specified for each zone that reflects the operation set named Existing Ops.

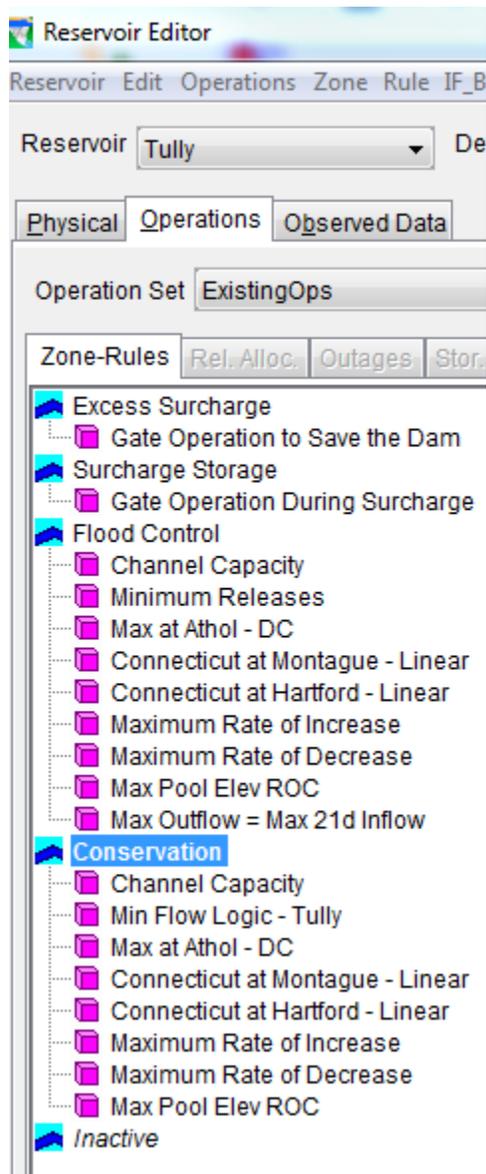


Figure 6: Reservoir Editor: Operations Tab – Existing Ops OpSet – Zones and Rules

## C. Rule Descriptions

### 1. Gate Operation to Save Dam

Figure 7 shows the content of “Gate Operation to Save Dam” rule. This rule represents the maximum allowable release from Slide gates as a function of pool elevation when the pool is in Excess Surcharge zone.

The screenshot shows the 'Operations Tab' in the Reservoir Editor. The 'ExistingOps' operation set is selected. The 'Zone-Rules' section is expanded to 'Excess Surcharge', where 'Gate Operation to Save the Dam' is highlighted. The main configuration area shows the rule name and description, the function 'Tully-Pool Elevation, Lagged Value, 48.0 hr lag', and the limit type 'Maxim...'. A table displays the release values for different elevations, and a graph plots these values. Below the graph are several checkboxes for advanced settings like 'Period Average Limit', 'Hour of Day Multiplier', etc.

| Elev (ft) | Release (cfs) |
|-----------|---------------|
| 672.0     | 0.0           |
| 673.0     | 500.0         |
| 674.0     | 760.0         |
| 675.0     | 850.0         |
| 676.0     | 900.0         |
| 679.0     | 900.0         |

Figure 7: Reservoir Editor: Operations Tab – Existing Ops OpSet –Gate Operation to Save Dam

## 2. Gate Operation During Surcharge

Figure 8 shows the content of “Gate Operation During Surcharge” rule. This rule represents the maximum allowable release from Tully as a function of pool elevation when the pool is in Surcharge storage zone.

The screenshot shows the 'Operations Tab' in the Reservoir Editor. The 'Operation Set' is 'ExistingOps'. The 'Zone-Rules' section is active, and 'Gate Operation During Surcharge' is selected. The configuration for this rule is as follows:

- Operates Release From: Tully-Tully River
- Rule Name: Operation During Surcharge
- Function of: Tully-Pool Elevation, Lagged Value, 48.0 hr lag
- Limit Type: Maxim... Interp.: Lin...

| Elev (ft) | Release (cfs) |
|-----------|---------------|
| 668.0     | 825.0         |
| 668.9     | 0.0           |
| 672.0     | 0.0           |
|           |               |
|           |               |
|           |               |
|           |               |
|           |               |
|           |               |
|           |               |

The graph on the right shows Release (cfs) on the y-axis (0 to 800) and Elev (ft) on the x-axis (668 to 672). A blue line starts at (668.0, 825.0) and drops to (668.9, 0.0), remaining at 0.0 cfs up to 672.0 ft.

Control buttons on the right include:
 

- Period Average Limit Edit...
- Hour of Day Multiplier Edit...
- Day of Week Multiplier Edit...
- Rising/Falling Condition Edit...
- Seasonal Variation Edit...

Figure 8: Reservoir Editor: Operations Tab – Existing Ops OpSet –Gate Operation During Surcharge

### 3. Channel Capacity

Figure 9 shows the content of “Channel Capacity” rule. This rule shows the maximum allowable release from Tully.

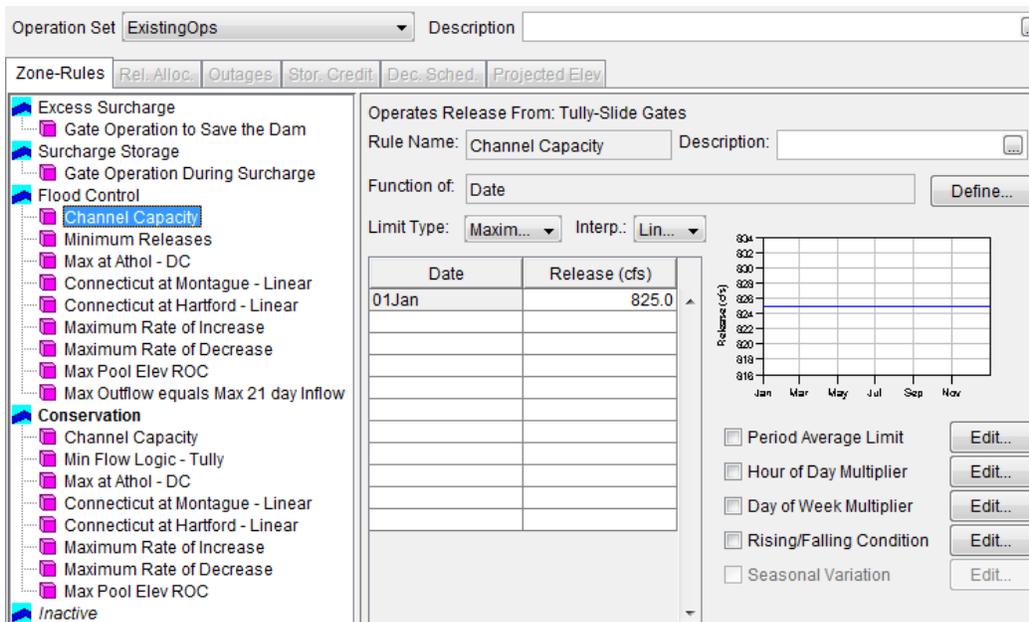


Figure 9: Reservoir Editor: Operations Tab – Existing Ops OpSet –Channel Capacity

### 4. Minimum Releases

Figure 10 shows the content of “Minimum Releases” rule. This rule shows the minimum required release from dam during flood control operations.

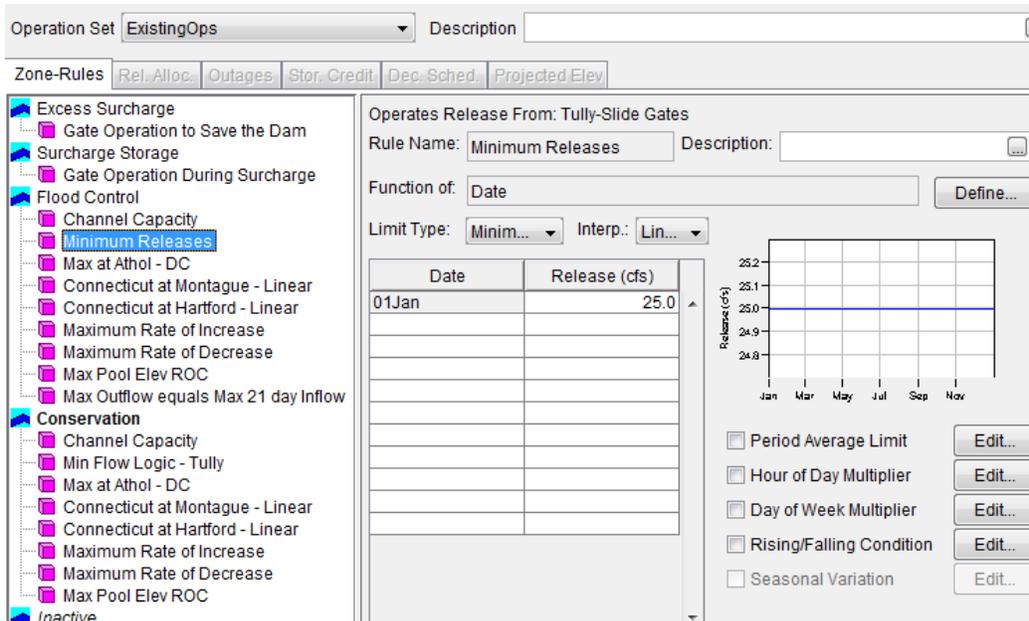


Figure 10: Reservoir Editor: Operations Tab – Existing Ops OpSet –Minimum Releases

### 5. Max at Athol-DC

Figure 11 shows the content of “Max at Athol-DC” rule. This rule shows the maximum allowable flow at the downstream location Millers at Athol.

The screenshot displays the 'Operations Tab' for an 'Existing Ops' set. The 'Max at Athol - DC' rule is selected in the sidebar. The main configuration area shows the following details:

- Operates Release From:** Tully
- Rule Name:** Max at Athol - DC
- Description:** (empty)
- Function of:** Date
- Limit Type:** Maximum
- Interp.:** Line
- Downstream Location:** Millers at Athol
- Parameter:** Flow

A data table below the configuration shows the flow limit for the first day of the year:

| Date  | Flow (cfs) |
|-------|------------|
| 01Jan | 2970.0     |
|       |            |
|       |            |
|       |            |
|       |            |
|       |            |
|       |            |
|       |            |
|       |            |
|       |            |

To the right of the table is a line graph showing 'Flow (cfs)' on the y-axis (ranging from 2,940 to 3,000) and months on the x-axis (Jan, Mar, May, Jul, Sep, Nov). A horizontal blue line is drawn at the 2,970 cfs level, corresponding to the value in the table.

Additional options on the right include checkboxes for 'Period Average Limit', 'Hour of Day Multiplier', 'Day of Week Multiplier', 'Seasonal Variation', and 'Flow Contingency', each with an 'Edit...' button. An 'Advanced Options' button is also present at the bottom.

Figure 11: Reservoir Editor: Operations Tab – Existing Ops OpSet –Max at Athol-DC

### 6. Connecticut at Montague-Linear

Figure 12 shows the content of “Connecticut at Montague-Linear” rule. This rule represents the maximum allowable release from the dam as a function of the previous day stage at Montague. The previous day stage was used to account for the delay that occurs between the stage exceeding the specified target and the change in operations at the flood control dams that occurs in reality.

The screenshot shows the 'Operations Tab' for the 'ExistingOps' operation set. The 'Zone-Rules' section on the left lists various rules, with 'Connecticut at Montague - Linear' selected. The main panel displays the configuration for this rule:

- Operates Release From:** Tully
- Rule Name:** cticut at Montague - Linear
- Function of:** Connecticut at Montague Stage, Previous Value
- Limit Type:** Maxim... **Interp.:** Lin...

| Stage (ft) | Release (cfs) |
|------------|---------------|
| 0.0        | 825.0         |
| 26.0       | 825.0         |
| 27.0       | 660.0         |
| 28.0       | 495.0         |
| 29.0       | 330.0         |
| 30.0       | 165.0         |
| 31.0       | 0.0           |
| 50.0       | 0.0           |

To the right of the table is a graph showing Release (cfs) on the y-axis (0 to 800) and Stage (ft) on the x-axis (0 to 50). The graph shows a constant release of 825 cfs until stage 26 ft, followed by a linear decrease to 0 cfs at stage 31 ft.

Below the graph are several checkboxes for advanced settings, each with an 'Edit...' button:

- Period Average Limit
- Hour of Day Multiplier
- Day of Week Multiplier
- Rising/Falling Condition
- Seasonal Variation

Figure 12: Reservoir Editor: Operations Tab – Existing Ops OpSet –Connecticut at Montague-Linear

### 7. Connecticut at Hartford-Linear

Figure 13 shows the content of “Connecticut at Hartford-Linear” rule. This rule represents the maximum allowable release from the dam as a function of the previous day stage at Hartford. The previous day stage was used to account for the delay that occurs between the stage exceeding the specified target and the change in operations at the flood control dams that occurs in reality.

Operation Set: ExistingOps Description:

Zone-Rules: Rel. Alloc. Outages Stor. Credit Dec. Sched. Projected Elev.

- Excess Surcharge
  - Gate Operation to Save the Dam
  - Surcharge Storage
  - Gate Operation During Surcharge
- Flood Control
  - Channel Capacity
  - Minimum Releases
  - Max at Athol - DC
  - Connecticut at Montague - Linear
  - Connecticut at Hartford - Linear
  - Maximum Rate of Increase
  - Maximum Rate of Decrease
  - Max Pool Elev ROC
  - Max Outflow equals Max 21 day Inflow
- Conservation
  - Channel Capacity
  - Min Flow Logic - Tully
  - Max at Athol - DC
  - Connecticut at Montague - Linear
  - Connecticut at Hartford - Linear
  - Maximum Rate of Increase
  - Maximum Rate of Decrease
  - Max Pool Elev ROC
- Inactive

Operates Release From: Tully

Rule Name: Connecticut at Hartford - Linear Description:

Function of: Connecticut at Hartford Stage, Previous Value Define...

Limit Type: Maxim... Interp.: Lin...

| Stage (ft) | Release (cfs) |
|------------|---------------|
| 0.0        | 825.0         |
| 18.0       | 825.0         |
| 19.0       | 660.0         |
| 20.0       | 495.0         |
| 21.0       | 330.0         |
| 22.0       | 165.0         |
| 23.0       | 0.0           |
| 50.0       | 0.0           |
|            |               |
|            |               |

Period Average Limit Edit...  
 Hour of Day Multiplier Edit...  
 Day of Week Multiplier Edit...  
 Rising/Falling Condition Edit...  
 Seasonal Variation Edit...

Figure 13: Reservoir Editor: Operations Tab – Existing Ops OpSet – Connecticut at Hartford-Linear

### 8. Maximum Rate of Increase

Figure 14 shows the content of “Maximum Rate of Increase” rule. This rule shows the maximum allowable increasing release rate of change as a function of release from Tully.

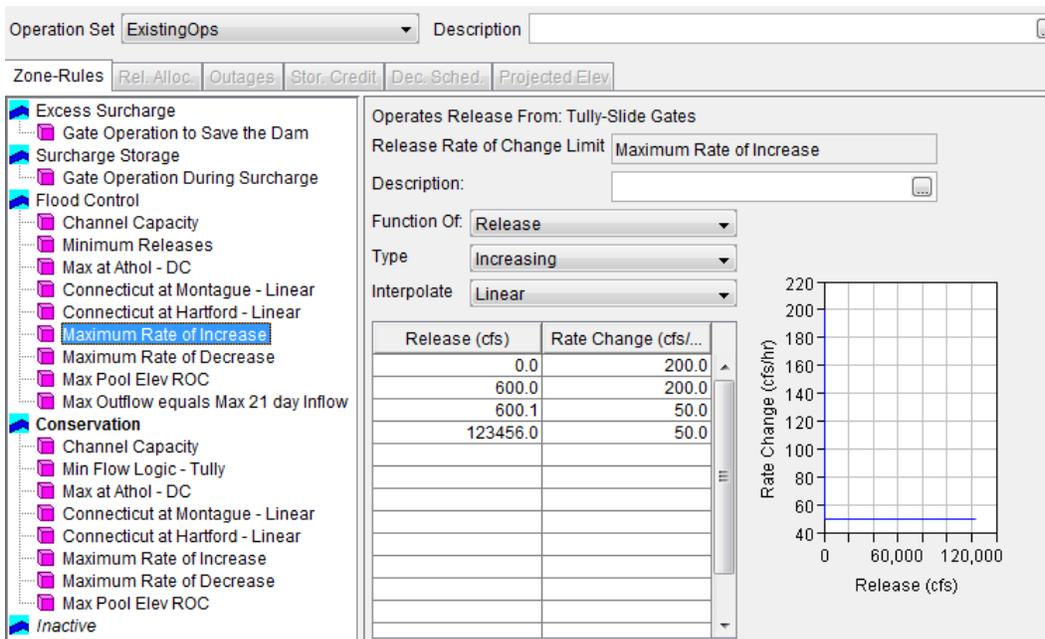


Figure 14: Reservoir Editor: Operations Tab – Existing Ops OpSet –Maximum Rate of Increase

### 9. Maximum Rate of Decrease

Figure 15 shows the content of “Maximum Rate of Decrease” rule. This rule shows the maximum allowable decreasing release rate of change.

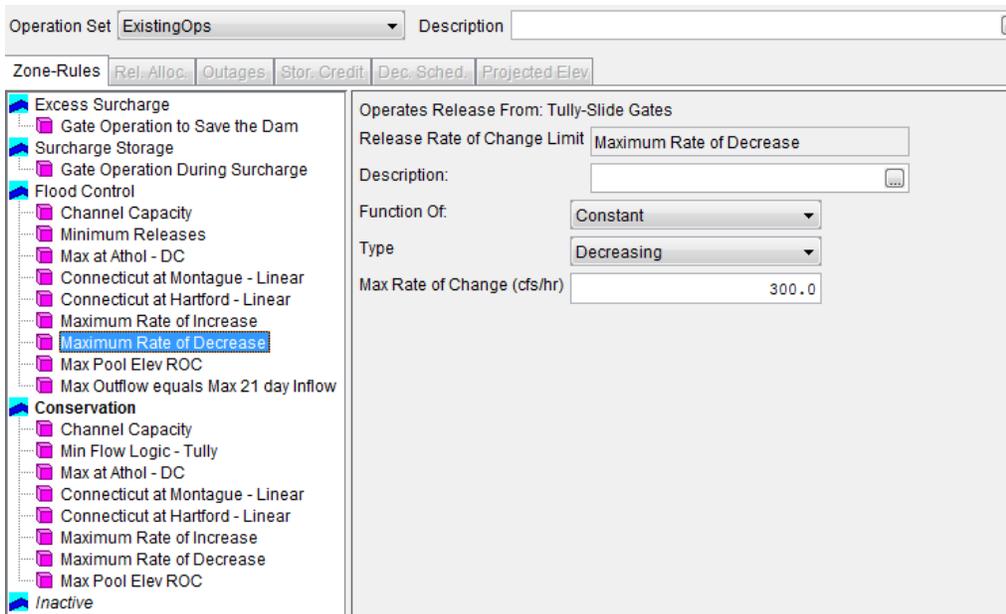


Figure 15: Reservoir Editor: Operations Tab – Existing Ops OpSet – Maximum Rate of Decrease

### 10. Max Pool Elev ROC

Figure 16 shows the content of “Max Pool Elev ROC” rule. This rule shows the maximum allowable decreasing pool elevation rate of change.

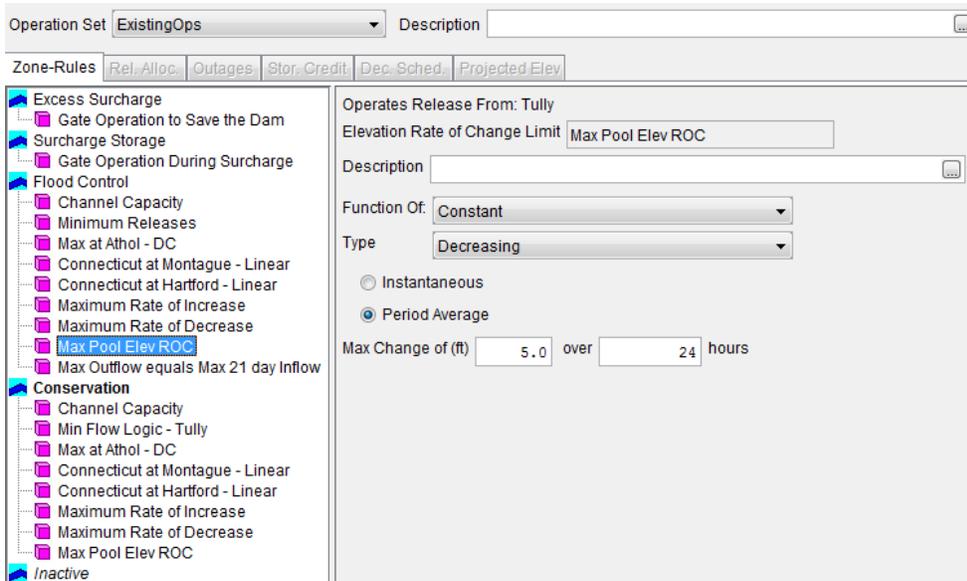


Figure 16: Reservoir Editor: Operations Tab – Existing Ops OpSet –Max Pool Elev ROC

### 11. Max Outflow equals Max 21 day Inflow

Figure 17 shows the content of “Max Outflow equals Max 21 day Inflow” rule. This rule represents the maximum release from dam as a function of the previous 3 weeks of inflow.

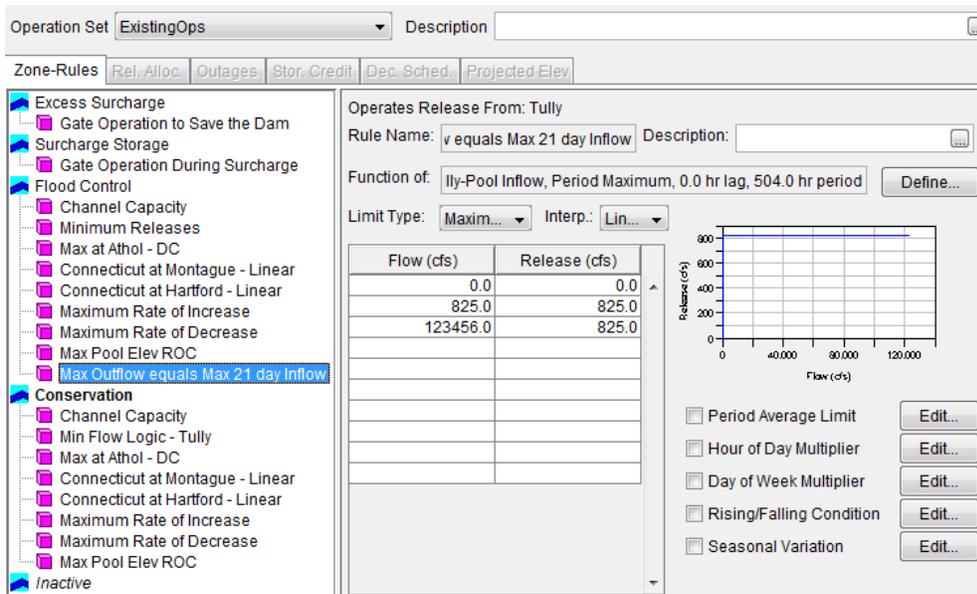


Figure 17: Reservoir Editor: Operations Tab – Existing Ops OpSet –Max Outflow equals Max 21 day Inflow

### 12. Min Flow Logic-Tully

Figure 18 shows the content of “Min Flow Logic-Tully” rule. This rule provides seasonal minimum releases from Tully as a function of inflow.

The screenshot shows the 'Operations Tab' for the 'ExistingOps' OpSet. The 'Zone-Rules' section is active, and the 'Min Flow Logic - Tully' rule is selected. The rule is configured to operate on 'Tully' with the function 'Tully-Pool Net Inflow, Current Value' and a 'Minimum' limit type with 'Linear' interpolation. A table defines the release values for different flow rates and dates. A graph plots Release (cfs) against Flow (cfs), showing a horizontal line at 50 cfs for flows above 200 cfs and a linear increase for lower flows.

| Flow (cfs) | Release (cfs) |         |        |        |
|------------|---------------|---------|--------|--------|
|            | 01Jan         | 01Apr   | 01Jun  | 01Oct  |
| 0.0        | 0.0           | 0.0     | 0.0    | 0.0    |
| 24.99      | 17.493        | 17.493  | 17.493 | 17.493 |
| 25.0       | 17.5          | 17.5    | 25.0   | 17.5   |
| 49.99      | 34.993        | 34.993  | 25.0   | 34.993 |
| 50.0       | 50.0          | 35.0    | 25.0   | 50.0   |
| 199.99     | 50.0          | 139.993 | 25.0   | 50.0   |
| 200.0      | 50.0          | 200.0   | 25.0   | 50.0   |
| 123456.0   | 50.0          | 200.0   | 25.0   | 50.0   |

Figure 18 Reservoir Editor: Operations Tab – Existing Ops OpSet –Min Flow Logic-Tully

# Turners Falls

## I. Overview

Turners Falls dam is located on the mainstem Connecticut River directly downstream of Northfield Mountain and the confluence with the Millers River. FirstLight Power Resources owns and operates Turners Falls which is used to generate hydropower at two downstream stations (one of those stations is modeled as a separate reservoir, Power Canal). It is also operated in connection with Northfield Mountain, another FirstLight Power Resources project.

Figure 1 shows the location of Turners Falls dam as it is represented in the HEC-ResSim model. Figure 2 shows a photo from Turners Falls dam.

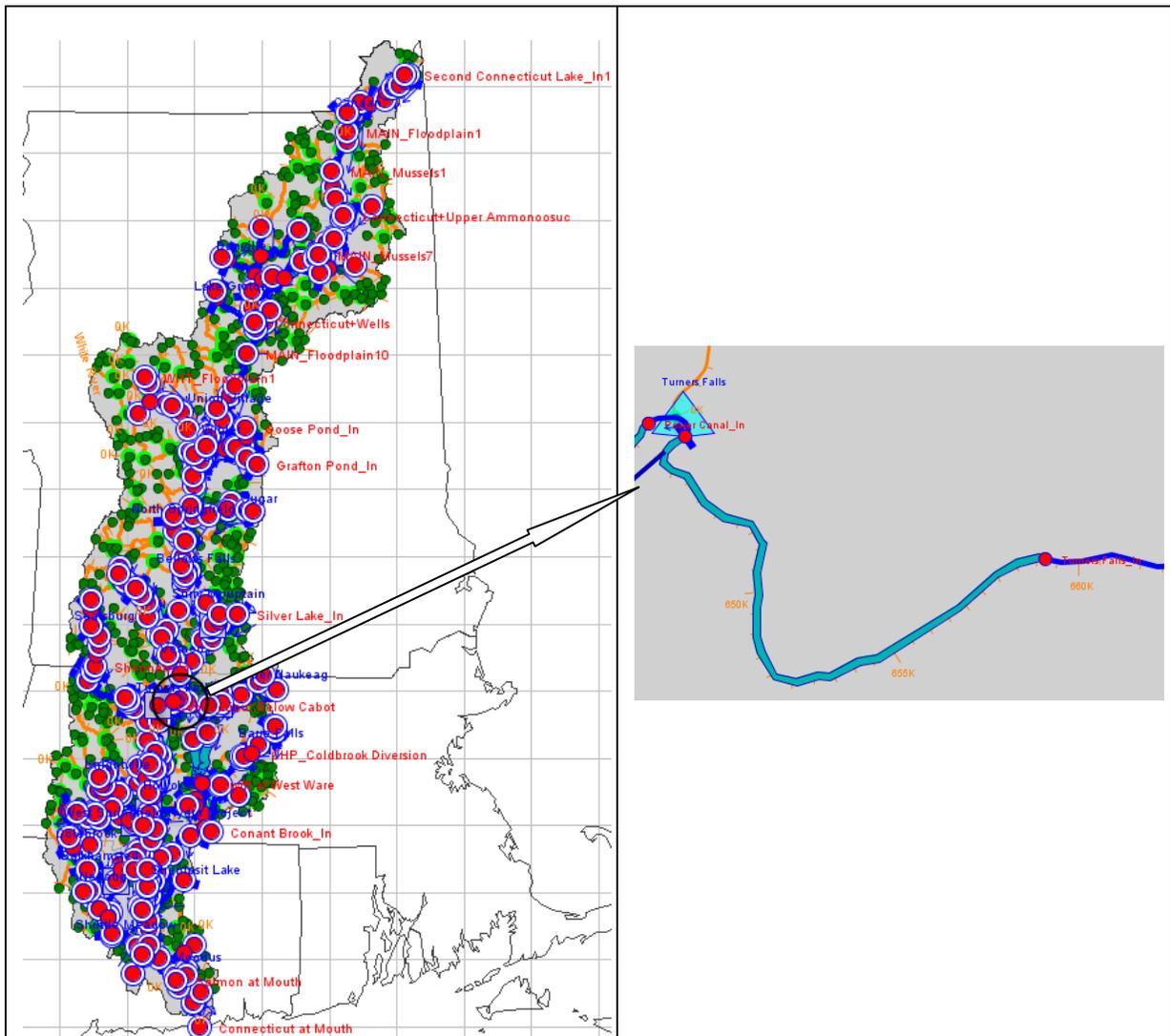


Figure 1: HEC-ResSim Map Display Showing Location of Turners Falls dam



Figure 2: Photo from Turners Falls dam

## II. Physical Characteristics

The physical characteristics of the reservoir are separated between the Pool and the Dam in the HEC-ResSim model. The elevation-storage-area defines the pool as shown in Figure 3<sup>99</sup>. The dam consists of two types of outlets: (1) controlled Gatehouse to Canal, and (2) controlled spillway Gates, as shown in Figure 4.

---

<sup>99</sup> All physical and operational data from ResSim model developed by Gomez and Sullivan Engineers, P.C.

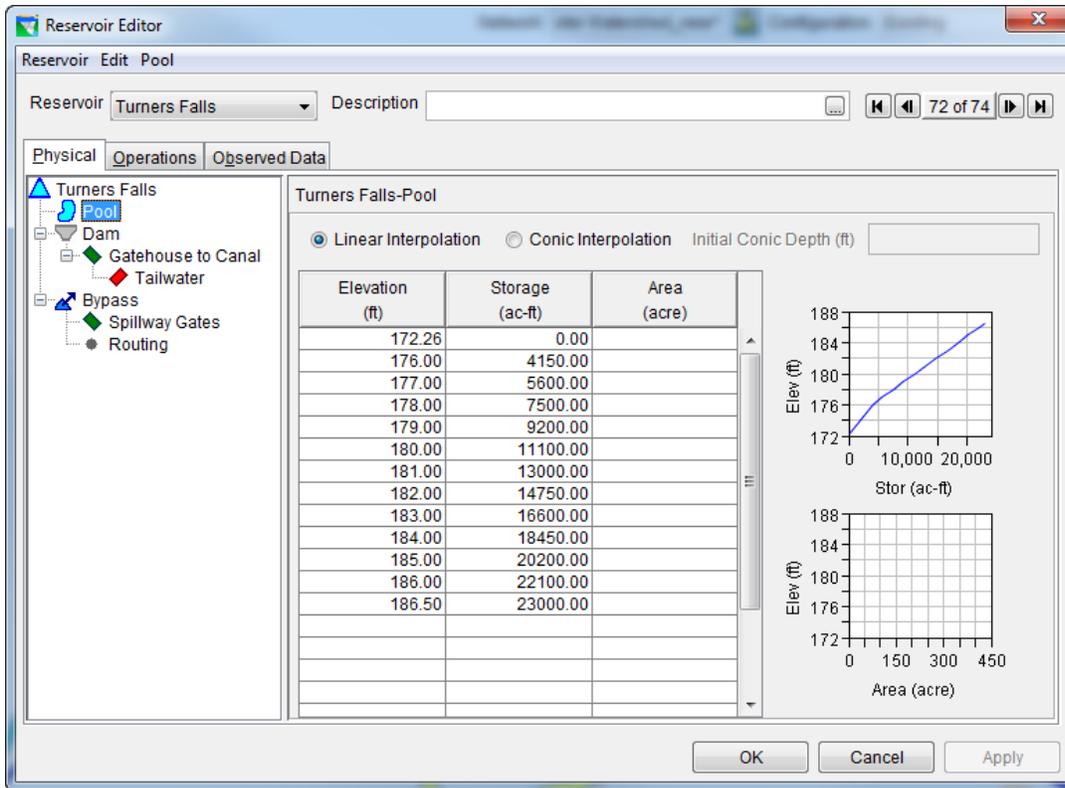


Figure 3: Reservoir Editor: Physical Tab -- Pool

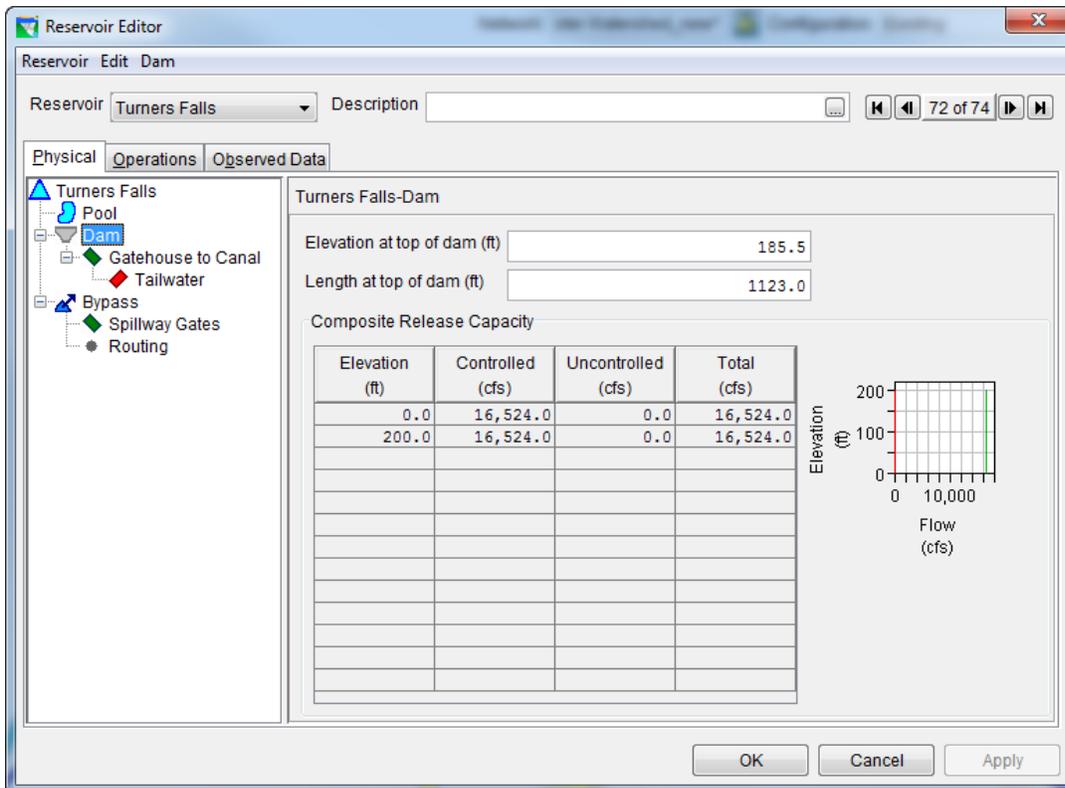


Figure 4: Reservoir Editor: Physical Tab -- Dam



## B. Rule Illustrations

Figure 6 shows a set of operational rules specified for each zone that reflects the operation set named Existing Ops.

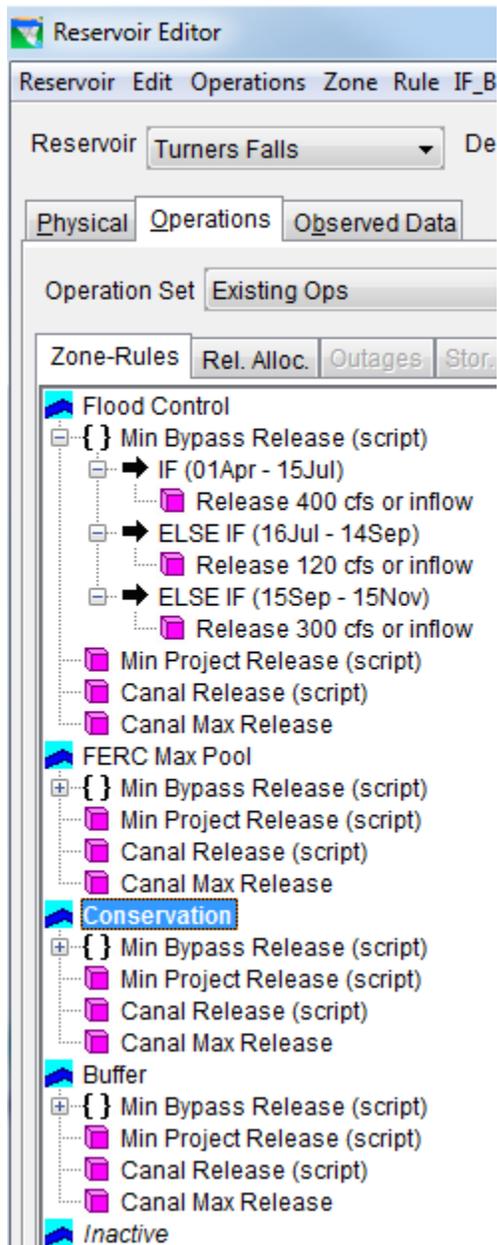


Figure 6: Reservoir Editor: Operations Tab – Existing Ops OpSet – Zones and Rules

## C. Rule Descriptions

### 1. Min Bypass Release(script)

Figure 7 shows the content of “Min Bypass Release (script)” rule. This script was created because the available Turners Falls pool inflow parameter includes generation flow from Northfield. This doesn't present too much of a problem with the current low min flow requirements because they are almost always exceeded, but could lead to issues with greater min flow requirements.

The screenshot displays a software interface for configuring a rule. It is divided into several sections:

- Top Section:** Shows the 'Operation Set' as 'Existing Ops' and a 'Description' field. Below this are tabs for 'Zone-Rules', 'Rel. Alloc.', 'Outages', 'Stor. Credit', 'Dec. Sched.', and 'Projected Elev.'.
- Left Panel (Tree View):** A tree structure under 'Flood Control' showing the rule 'Min Bypass Release (script)'. It lists four conditions: 'IF (01Apr - 15Jul)', 'ELSE IF (16Jul - 14Sep)', 'ELSE IF (15Sep - 15Nov)', and 'Release 300 cfs or inflow'.
- Right Panel (Configuration):**
  - Operates Release From: Turners Falls-Bypass
  - Name: n Bypass Release (script) | Description: This script was created because the available Turners Falls pool...
  - Table of conditions:

| Type    | Name          | Description |
|---------|---------------|-------------|
| IF      | 01Apr - 15Jul |             |
| ELSE IF | 16Jul - 14Sep |             |
| ELSE IF | 15Sep - 15Nov |             |
- Code Editor (Middle):** A script starting with line 13:

```

13 # create new Operation Value (OpValue) to return
14 opValue = OpValue()
15
16 # Calculate the natural inflow of Turners Falls (not including pump/gen flow from Northfield).
17 criver_at_pauchaug = network.getTimeSeries("Junction","Connecticut+Pauchaug", "", "Flow").getCurrentValue(currentRuntimeStep)
18 millers_at_mouth = network.getTimeSeries("Junction","Millers at Mouth", "", "Flow").getCurrentValue(currentRuntimeStep)
19 ctlocal_at_millers = network.findJunction("Connecticut+Millers").getLocalFlowTimeSeries("SYE CONNECTICUT+MILLERS").getLocalFlowTimeSeries(currentRuntimeStep)
20 TF_naturalinflow = criver_at_pauchaug + millers_at_mouth + ctlocal_at_millers
21 #julian_day = currentRuntimeStep.dayOfYear()
22
23 # set type and value for OpValue
24 # type is one of:
25 # OpRule.RULETYPE_MAX - maximum flow
26 # OpRule.RULETYPE_MIN - minimum flow
27 # OpRule.RULETYPE_SPEC - specified flow
28 #if julian_day > '1'
29 if TF_naturalinflow < 400:
30     opValue.init(OpRule.RULETYPE_MIN, TF_naturalinflow)
31 else:
32     opValue.init(OpRule.RULETYPE_MIN, 400)
33
34 # return the Operation Value.
35 # return "None" to have no effect on the compute
36 return opValue

```
- Bottom Section:** Similar to the top section, showing 'Operation Set' as 'Existing Ops' and 'Description'. The 'Zone-Rules' tabs are present. The left panel shows the rule tree with 'ELSE IF (16Jul - 14Sep)' selected. The right panel shows:
  - Operates Release From: Turners Falls-Bypass
  - ELSE IF Conditional: 16Jul - 14Sep | Description:
  - Table of conditions:

| Value1                | Value2   |
|-----------------------|----------|
| Current Time Step     | >= 16Jul |
| AND Current Time Step | < 15Sep  |

```

13 # create new Operation Value (OpValue) to return
14 opValue = OpValue()
15
16 # Calculate the natural inflow of Turners Falls (not including pump/gen flow from Northfield).
17 ctriver_at_pauchaug = network.getTimeSeries("Junction","Connecticut+Pauchaug", "", "Flow").getCurrentValue(currentRuntimestep)
18 millers_at_mouth = network.getTimeSeries("Junction","Millers at Mouth", "", "Flow").getCurrentValue(currentRuntimestep)
19 ctlocal_at_millers = network.findJunction("Connecticut+Millers").getLocalFlowTimeSeries("SYE CONNECTICUT+MILLERS").getCurrentValue(currentRuntimestep)
20 TF_naturalinflow = ctriver_at_pauchaug + millers_at_mouth + ctlocal_at_millers
21
22 # set type and value for OpValue
23 # type is one of:
24 # OpRule.RULETYPE_MAX - maximum flow
25 # OpRule.RULETYPE_MIN - minimum flow
26 # OpRule.RULETYPE_SPEC - specified flow
27 if TF_naturalinflow < 120:
28     opValue.init(OpRule.RULETYPE_MIN, TF_naturalinflow)
29 else:
30     opValue.init(OpRule.RULETYPE_MIN, 120)
31
32 # return the Operation Value.
33 # return "None" to have no effect on the compute
34 return opValue
    
```

Operation Set: Existing Ops Description:

Zone-Rules: Rel. Alloc. Outages Stor. Credit Dec. Sched. Projected Elev

**Flood Control**

- Min Bypass Release (script)
  - IF (01Apr - 15Jul)
    - Release 400 cfs or inflow
  - ELSE IF (16Jul - 14Sep)
    - Release 120 cfs or inflow
  - ELSE IF (15Sep - 15Nov)**
    - Release 300 cfs or inflow

Operates Release From: Turners Falls-Bypass

ELSE IF Conditional: 15Sep - 15Nov Description:

|     | Value1            |    | Value2 |
|-----|-------------------|----|--------|
|     | Current Time Step | >= | 15Sep  |
| AND | Current Time Step | <  | 16Nov  |

Add Cond.

```

13 # create new Operation Value (OpValue) to return
14 opValue = OpValue()
15
16 # Calculate the natural inflow of Turners Falls (not including pump/gen flow from Northfield).
17 ctriver_at_pauchaug = network.getTimeSeries("Junction","Connecticut+Pauchaug", "", "Flow").getCurrentValue(currentRuntimestep)
18 millers_at_mouth = network.getTimeSeries("Junction","Millers at Mouth", "", "Flow").getCurrentValue(currentRuntimestep)
19 ctlocal_at_millers = network.findJunction("Connecticut+Millers").getLocalFlowTimeSeries("SYE CONNECTICUT+MILLERS").getCurrentValue(currentRuntimestep)
20 TF_naturalinflow = ctriver_at_pauchaug + millers_at_mouth + ctlocal_at_millers
21
22 # set type and value for OpValue
23 # type is one of:
24 # OpRule.RULETYPE_MAX - maximum flow
25 # OpRule.RULETYPE_MIN - minimum flow
26 # OpRule.RULETYPE_SPEC - specified flow
27 if TF_naturalinflow < 300:
28     opValue.init(OpRule.RULETYPE_MIN, TF_naturalinflow)
29 else:
30     opValue.init(OpRule.RULETYPE_MIN, 300)
31
32 # return the Operation Value.
33 # return "None" to have no effect on the compute
34 return opValue
    
```

Figure 7: Reservoir Editor: Operations Tab – Existing Ops OpSet – Min Bypass Release (script)

## 2. Min Project Release(script)

Figure 8 shows the content of “Min Project Release (script)” rule. Release 1433 cfs or inflow, whichever is less, from the Turners Falls Project (primarily released from canal). This script was created because the available Turners Falls pool inflow parameter includes generation flow from Northfield. This doesn't present too much of a problem with a min flow of 1433 cfs because it is almost always exceeded, but could lead to issues with greater min flow requirements.

The screenshot shows the 'Existing Ops' tab in the Reservoir Editor. The 'Min Project Release (script)' rule is selected in the left-hand pane. The right-hand pane displays the rule's configuration and its code. The configuration includes the name 'Min Project Release (script)', the description 'Release 1433 cfs or inflow, whichever is less, from the Turners Falls Project (primarily released from canal). This script was created because the available...', and the script operation rule 'Min Project Release (script)'. The code is as follows:

```

13 # create new Operation Value (OpValue) to return
14 opValue = OpValue()
15
16 # Calculate the natural inflow of Turners Falls (not including pump/gen flow from Northfield).
17 ctriver_at_pauchaug = network.getTimeSeries("Junction","Connecticut+Pauchaug", "", "Flow").getCurrentValue(currentRuntimestep)
18 millers_at_mouth = network.getTimeSeries("Junction","Millers at Mouth", "", "Flow").getCurrentValue(currentRuntimestep)
19 ctlocal_at_millers = network.findJunction("Connecticut+Millers").getLocalFlowTimeSeries("SYE CONNECTICUT+MILLERS").getCurrentValue(currentRuntimestep)
20 TF_naturalinflow = ctriver_at_pauchaug + millers_at_mouth + ctlocal_at_millers
21
22 # set type and value for OpValue
23 # type is one of:
24 # OpRule.RULETYPE_MAX - maximum flow
25 # OpRule.RULETYPE_MIN - minimum flow
26 # OpRule.RULETYPE_SPEC - specified flow
27 if TF_naturalinflow < 1433:
28     opValue.init(OpRule.RULETYPE_MIN, TF_naturalinflow)
29 else:
30     opValue.init(OpRule.RULETYPE_MIN, 1433)
31
32 # return the Operation Value.
33 # return "None" to have no effect on the compute
34 return opValue

```

Figure 8: Reservoir Editor: Operations Tab – Existing Ops OpSet – Min Project Release (script)

### 3. Canal Release(script)

Figure 9 shows the content of “Canal release (script)” rule. When combined usable storage is < 12318 (Northfield's effective storage), only release required fishway flows to the Power Canal.

The screenshot displays the 'Operations Tab' in the Reservoir Editor. The 'Existing Ops' set is selected, and the 'Canal Release (script)' rule is highlighted in the list. The rule's description is: 'When combined usable storage is < 12318 (Northfield's effective storage), only release required fishway flows to the Power Canal.' The script code is as follows:

```

13 # create new Operation Value (OpValue) to return
14 opValue = OpValue()
15
16 # When combined usable storage is < 12318 (Northfield's effective storage), only release required fishway flows to the Power Canal
17 NF_storage = network.getTimeSeries("Reservoir","Northfield", "Pool", "Stor").getCurrentValue(currentRuntimestep)
18 TF_storage = network.getTimeSeries("Reservoir","Turners Falls", "Pool", "Stor").getCurrentValue(currentRuntimestep)
19 combined_storage = NF_storage + TF_storage
20 #TF_inflow = network.getTimeSeries("Reservoir","Turners Falls", "Pool", "Flow-IN").getCurrentValue(currentRuntimestep)
21
22 cabot_capacity = 13728
23 stal_capacity = 2210
24 fishway_outflow = network.getTimeSeries("Reservoir","Power Canal", "Canal Fishways-Fishway Releases", "Flow-SPEC").getCurrentValue(currentRuntimestep)
25
26
27
28 # set type and value for OpValue
29 # type is one of:
30 # OpRule.RULETYPE_MAX - maximum flow
31 # OpRule.RULETYPE_MIN - minimum flow
32 # OpRule.RULETYPE_SPEC - specified flow
33 if combined_storage <= 12318:
34     opValue.init(OpRule.RULETYPE_MAX, fishway_outflow)
35 else:
36     opValue.init(OpRule.RULETYPE_MAX, cabot_capacity + stal_capacity + fishway_outflow)
37
38 # return the Operation Value.
39 # return "None" to have no effect on the compute
40 return opValue

```

Figure 9: Reservoir Editor: Operations Tab – Existing Ops OpSet – Canal release (script)

#### 4. Canal Max Release

Figure 10 shows the content of “Canal Max Release” rule. This rule caps the release to the canal at the capacity of Cabot + Station 1, plus any required fishway flows. It is redundant with the scripted Canal Release rule, but without this rule, the Min Project Release scripted rule somehow causes the canal to receive more flow than its current capacity, leading to spikes in the canal elevation. (The non-scripted version of the min project release rule, called Min Flow below Cabot, does not cause this problem, but its inflow parameter includes generation flow from Northfield, which could lead to issues with greater min flow requirements.)

The screenshot shows the 'Canal Max Release' rule configuration in the Reservoir Editor. The main configuration area includes the following details:

- Operates Release From:** Turners Falls-Gatehouse to Canal
- Rule Name:** Canal Max Release
- Description:** This rule caps the release to the c...
- Function of:** Power Canal-Canal Fishways-Fishway Releases Req Flow, Cu
- Limit Type:** Maximum
- Interp.:** Step

| Flow (cfs) | Release (cfs) |
|------------|---------------|
| 0.0        | 15938.0       |
| 200.0      | 16138.0       |
| 386.0      | 16324.0       |
| 586.0      | 16524.0       |
|            |               |
|            |               |
|            |               |
|            |               |
|            |               |
|            |               |
|            |               |

The graph on the right shows a step function where Release (cfs) increases in discrete steps as Flow (cfs) increases. The y-axis ranges from 16,000 to 16,600 cfs, and the x-axis ranges from 0 to 600 cfs.

Additional controls on the right include:

- Period Average Limit (Edit...)
- Hour of Day Multiplier (Edit...)
- Day of Week Multiplier (Edit...)
- Rising/Falling Condition (Edit...)
- Seasonal Variation (Edit...)

Figure 10: Reservoir Editor: Operations Tab – Existing Ops OpSet – Canal Max Release

# Union Village

## I. Overview

Union Village is a dam located in Thetford, Vermont on the Ompompanuoc River. It was constructed in 1950 by the US Army Corps of Engineers and is still owned and operated by the Corps. It is primarily used for flood control but is also used for recreation.

Figure 1 shows the location of Union Village Dam as it is represented in the HEC-ResSim model. Figure 2 shows a photo from Union Village Dam.

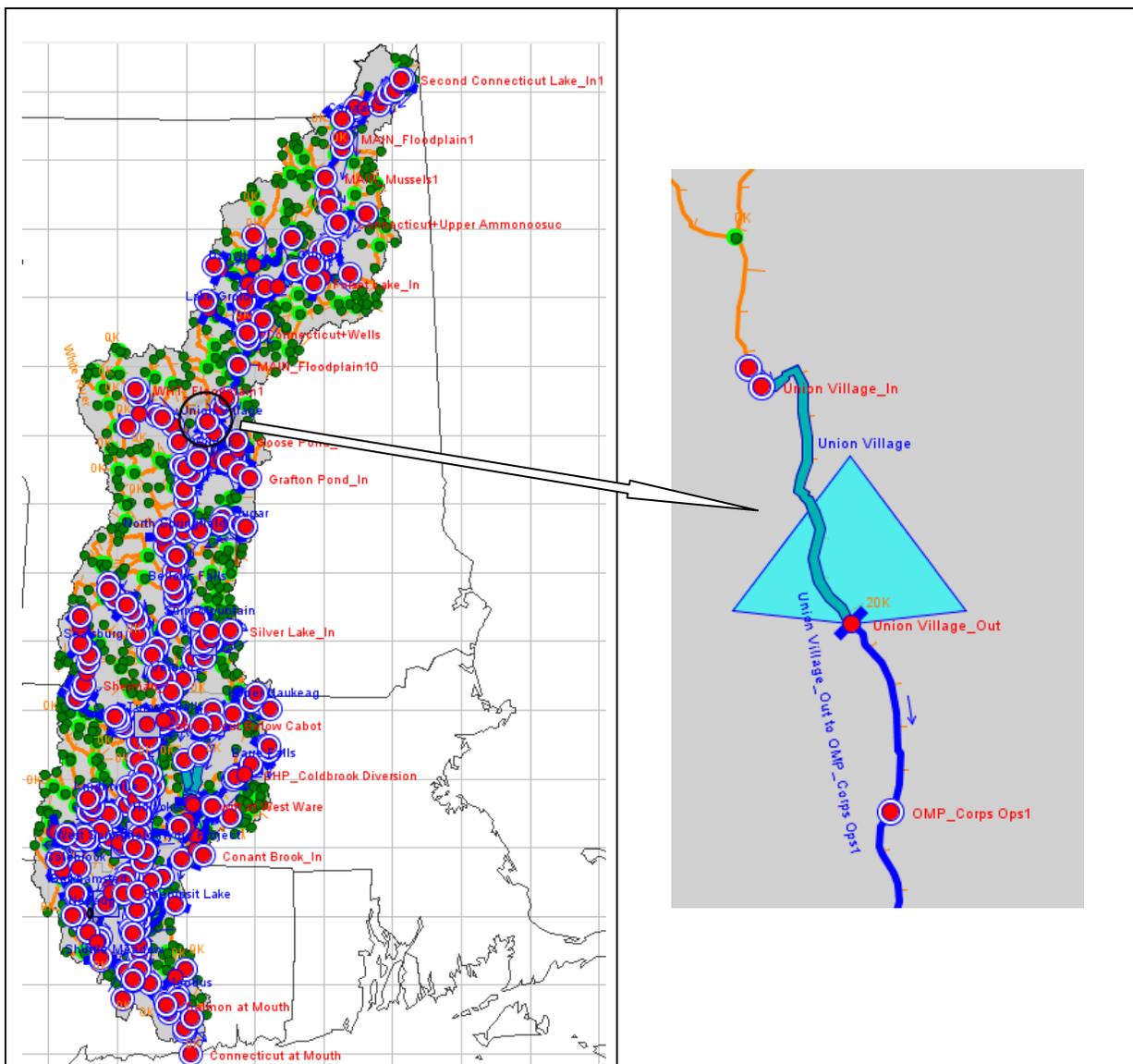


Figure 1: HEC-ResSim Map Display Showing Location of Union Village dam



Figure 2: Photo of Union Village dam.

## II. Physical Characteristics

The physical characteristics of the reservoir are separated between the Pool and the Dam in the HEC-ResSim model. The elevation-storage-area defines the pool as shown in Figure 3. The dam consists of two types of outlets: (1) controlled Slide gates, and (2) uncontrolled Spillway, as shown in Figure 4. All physical and operations data were provided by US Army Corps New England District, through both a previously created ResSim model and the Reservoir Regulation Team website<sup>100</sup>.

<sup>100</sup> [http://rsgisias.crrel.usace.army.mil/nae/cwms\\_map.map\\_index](http://rsgisias.crrel.usace.army.mil/nae/cwms_map.map_index)

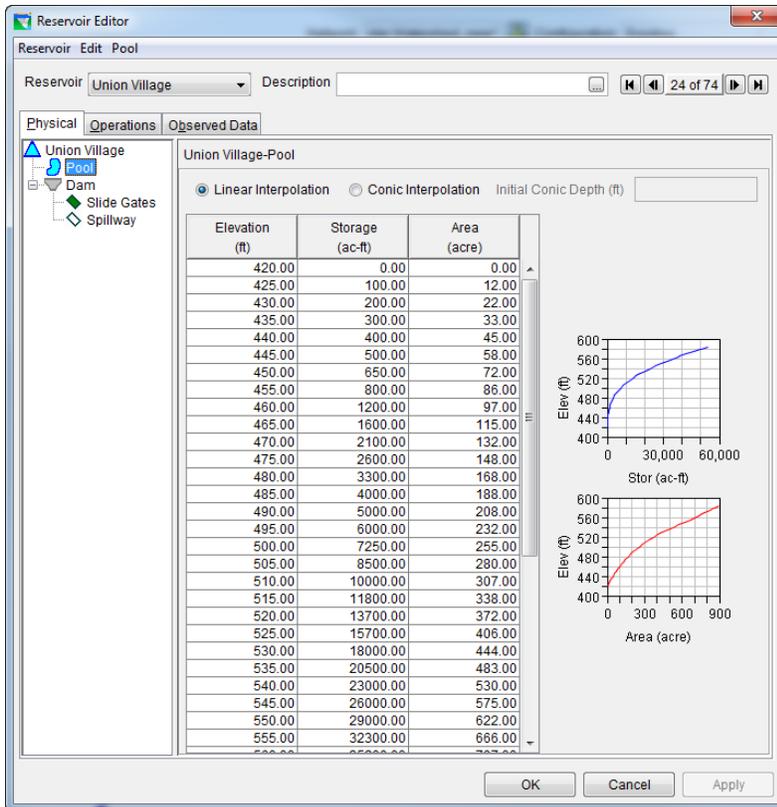


Figure 3: Reservoir Editor: Physical Tab -- Pool

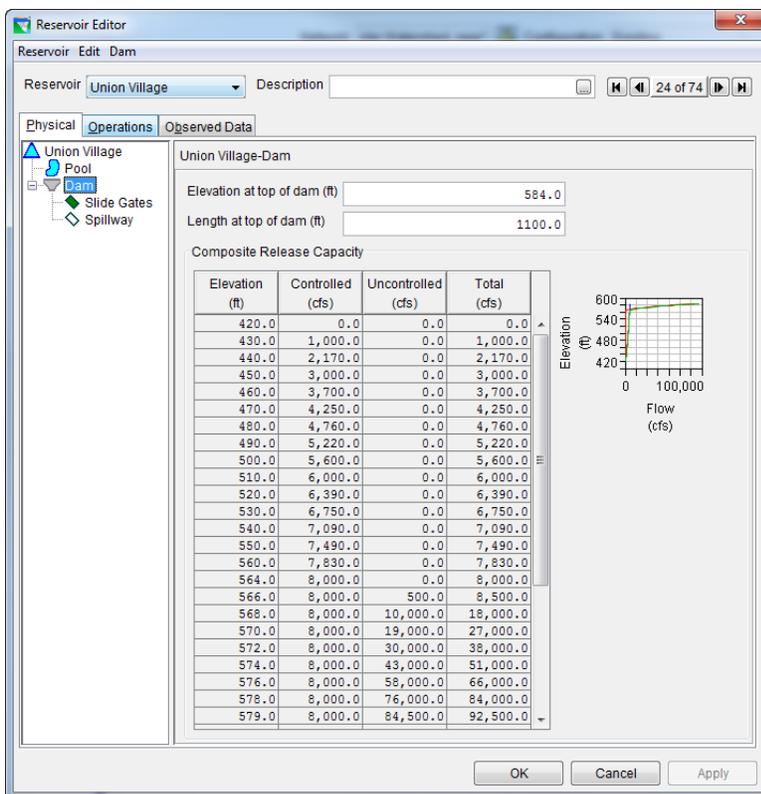


Figure 4: Reservoir Editor: Physical Tab -- Dam

### III. Operations

#### A. Operation Set

Zones are used to define the operational storage in the reservoir to determine the reservoir release through analysis of the rules contained within each zone. Figure 5 shows the definition of Union Village’s “ExistingOps” operational zones, which consist of zones of Top of dam (584 ft), Flood Control (564 ft), Conservation (421-440 ft), and Inactive zone (420 ft).

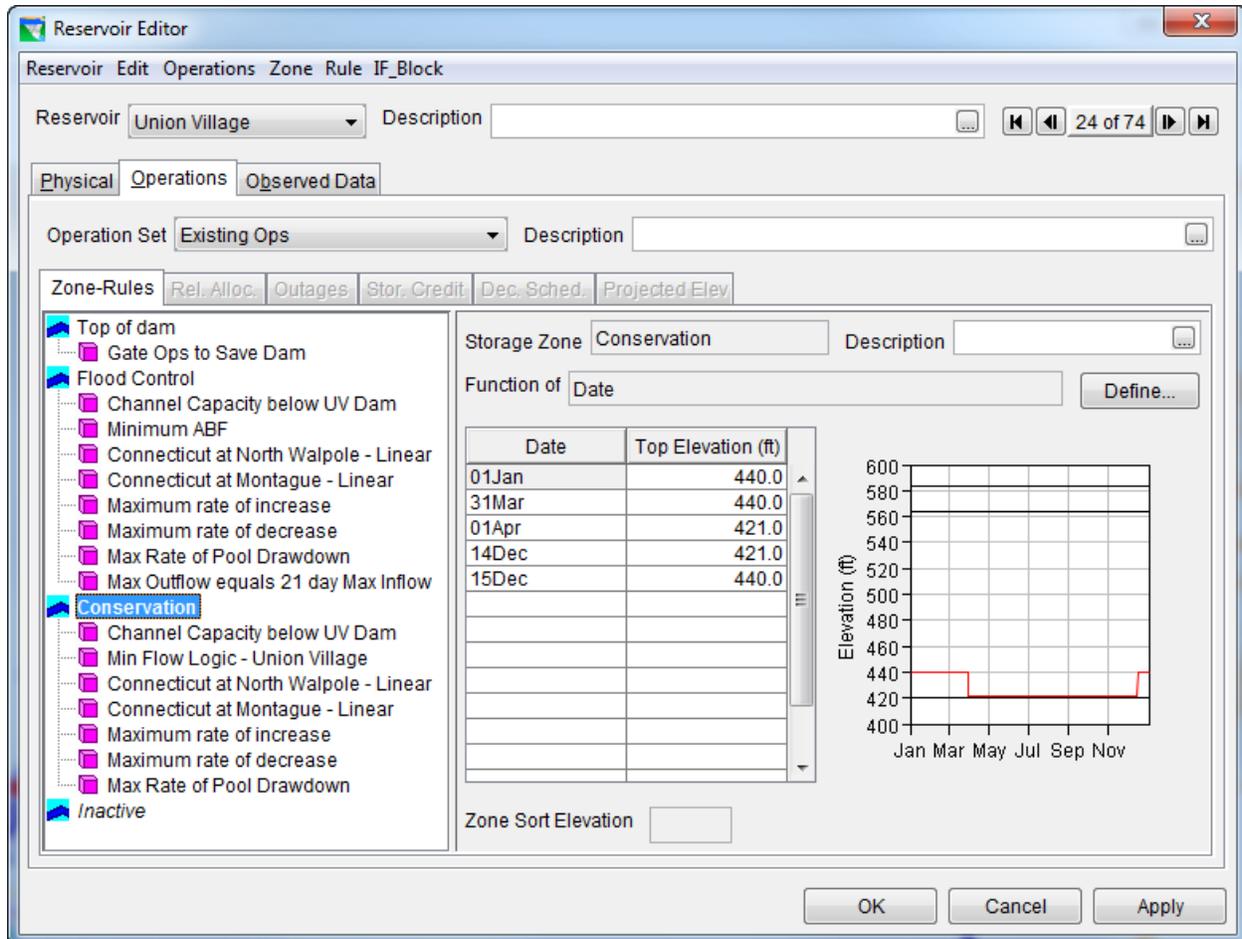


Figure 5: Reservoir Editor: Operations Tab –Existing Ops OpSet – Guide Curve

## B. Rule Illustrations

Figure 6 shows a set of operational rules specified for each zone that reflects the operation set named Existing Ops. As described in the Simulation/Verification section of the report, adjustments were made to the operations to closer match gauge data.

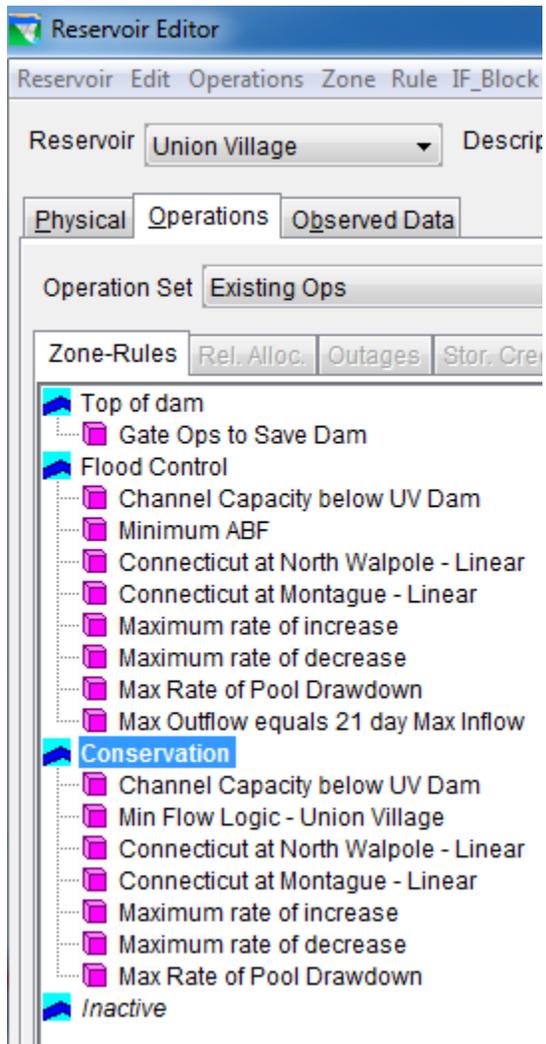


Figure 6: Reservoir Editor: Operations Tab – Existing Ops OpSet – Zones and Rules

## C. Rule Descriptions

### 1. Gate Ops to Save Dam

Figure 7 shows the content of “Gate ops to save Dam” rule. This rule represents the maximum allowable release from slide gates as a function of pool elevation when the pool is in Top of dam zone.

The screenshot displays the 'Operations Tab' for an 'Existing Ops' set. The 'Zone-Rules' section is expanded to 'Top of dam', where 'Gate Ops to Save Dam' is selected. The rule configuration panel shows the following details:

- Operates Release From:** Union Village-Slide Gates
- Rule Name:** Gate Ops to Save Dam
- Function of:** Pool Elevation, Period Average, 0.0 hr lag, 48.0 hr period
- Limit Type:** Maximum
- Interp.:** Linear

The graph shows the release rate (cfs) as a function of pool elevation (ft). The release starts at 2400.0 cfs at 564.0 ft, drops to 900.0 cfs at 565.0 ft, and then increases to a maximum of 8500.0 cfs at 572.0 ft, remaining constant up to 584.0 ft.

| Elev (ft) | Release (cfs) |
|-----------|---------------|
| 564.0     | 2400.0        |
| 565.0     | 900.0         |
| 565.5     | 0.0           |
| 568.0     | 0.0           |
| 569.0     | 4000.0        |
| 570.0     | 7600.0        |
| 571.0     | 7950.0        |
| 572.0     | 8300.0        |
| 575.0     | 8500.0        |
| 579.0     | 8500.0        |
| 584.0     | 8500.0        |

Figure 7: Reservoir Editor: Operations Tab – Existing Ops OpSet – Gate Ops to Save Dam



#### 4. Connecticut at North Walpole-Linear

Figure 10: shows the content of “Connecticut at North Walpole-Linear” rule. This rule represents the maximum allowable release from the dam as a function of the previous day stage at North Walpole. The previous day stage was used to account for the delay that occurs between the stage exceeding the specified target and the change in operations at the flood control dams that occurs in reality.

Operation Set: Existing Ops | Description: [ ]

Zone-Rules: Rel. Alloc. | Outages | Stor. Credit | Dec. Sched. | Projected Elev

Operates Release From: Union Village

Rule Name: t at North Walpole - Linear | Description: [ ]

Function of: Connecticut at North Walpole Stage, Previous Value | Define...

Limit Type: Maxi... | Interp.: Li...

| Stage (ft) | Release (cfs) |
|------------|---------------|
| 0.0        | 2400.0        |
| 24.0       | 2400.0        |
| 25.0       | 1920.0        |
| 26.0       | 1440.0        |
| 27.0       | 960.0         |
| 28.0       | 480.0         |
| 29.0       | 0.0           |
| 50.0       | 0.0           |

Release (cfs) vs. Stage (ft) graph showing a linear decrease from 2400.0 cfs at 0.0 ft to 0.0 cfs at 30.0 ft.

Period Average Limit | Edit...  
 Hour of Day Multiplier | Edit...  
 Day of Week Multiplier | Edit...  
 Rising/Falling Condition | Edit...  
 Seasonal Variation | Edit...

Figure 10: Reservoir Editor: Operations Tab – Existing Ops OpSet – Connecticut at North Walpole-Linear

### 5. Connecticut at Montague-Linear

Figure 11 shows the content of “Connecticut at Montague-Linear” rule. This rule represents the maximum allowable release from the dam as a function of the previous day stage at Montague. The previous day stage was used to account for the delay that occurs between the stage exceeding the specified target and the change in operations at the flood control dams that occurs in reality.

The screenshot shows the 'Operations Tab' in the Reservoir Editor. The 'Existing Ops' operation set is selected. The 'Connecticut at Montague-Linear' rule is highlighted in the tree view. The rule configuration is as follows:

- Operates Release From: Union Village
- Rule Name: cticut at Montague - Linear
- Function of: Connecticut at Montague Stage, Previous Value
- Limit Type: Maxi... Interp.: Li...

| Stage (ft) | Release (cfs) |
|------------|---------------|
| 0.0        | 2400.0        |
| 25.0       | 2400.0        |
| 26.0       | 1920.0        |
| 27.0       | 1440.0        |
| 28.0       | 960.0         |
| 29.0       | 480.0         |
| 30.0       | 0.0           |
| 50.0       | 0.0           |

The graph on the right shows Release (cfs) on the y-axis (0 to 2,000) and Stage (ft) on the x-axis (0 to 50). The release is constant at 2400 cfs until stage 25 ft, then decreases linearly to 0 cfs at stage 30 ft, and remains at 0 cfs thereafter.

Additional options on the right include checkboxes for Period Average Limit, Hour of Day Multiplier, Day of Week Multiplier, Rising/Falling Condition, and Seasonal Variation, each with an 'Edit...' button.

Figure 11: Reservoir Editor: Operations Tab – Existing Ops OpSet – Connecticut at Montague-Linear

### 6. Maximum rate of increase

Figure 12 shows the content of “Maximum rate of increase” rule. This rule shows the maximum allowable increasing release rate of change as a function of release from Union Village dam.

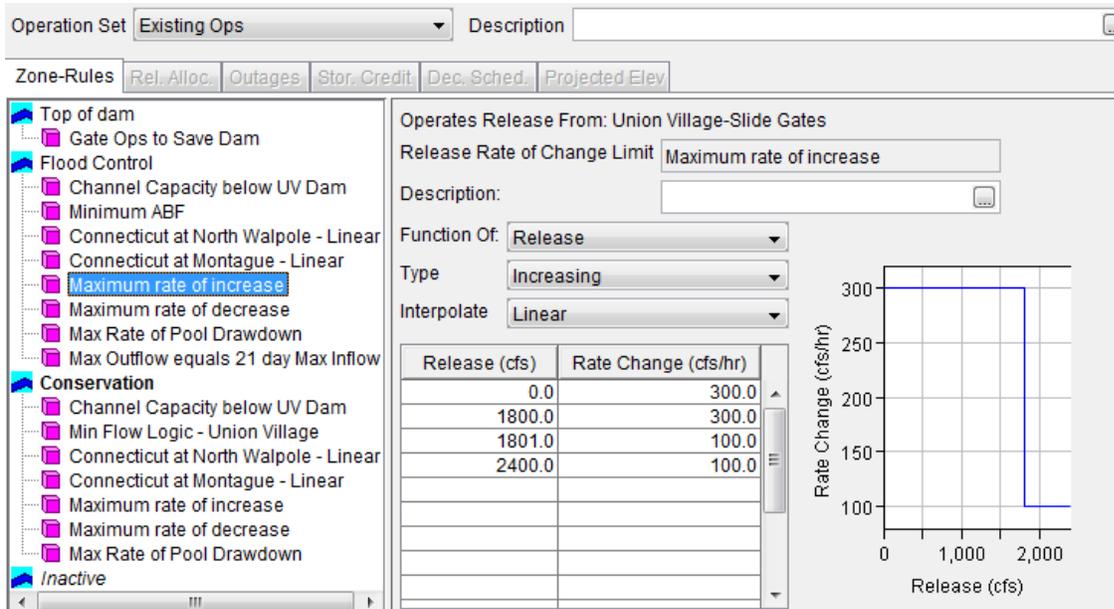


Figure 12: Reservoir Editor: Operations Tab – Existing Ops OpSet – Maximum rate of increase

### 7. Maximum rate of decrease

Figure 13 shows the content of “Maximum rate of decrease” rule. This rule shows the maximum allowable decreasing release rate of change.

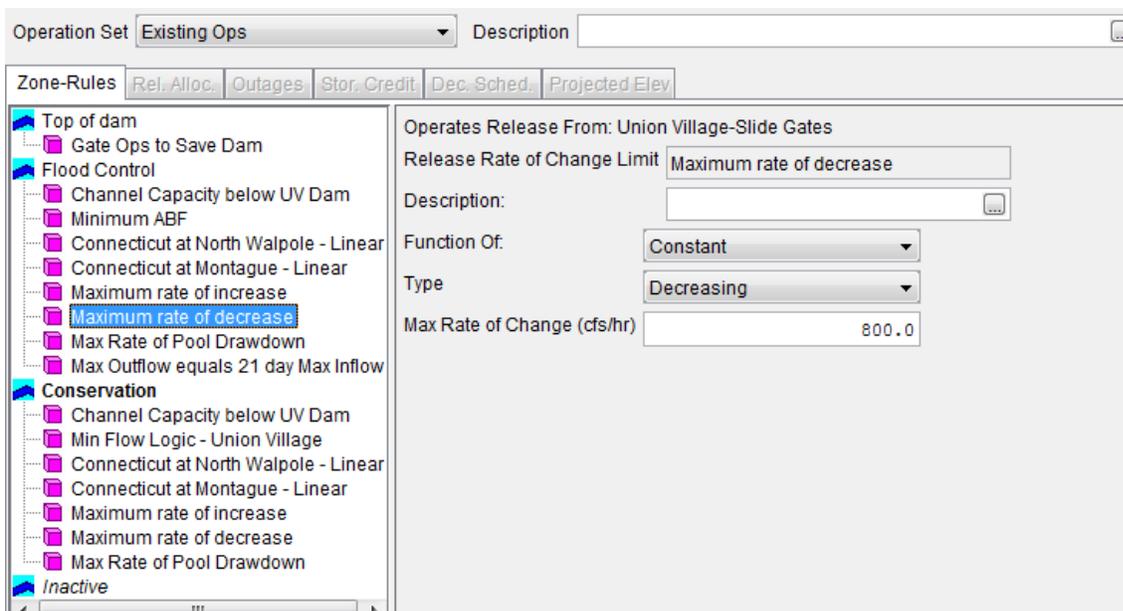


Figure 13: Reservoir Editor: Operations Tab – Existing Ops OpSet – Maximum rate of decrease

### 8. Max Rate of pool Drawdown

Figure 13 shows the content of “Max Rate of pool Drawdown” rule. This rule shows the maximum allowable decreasing pool elevation rate of change.

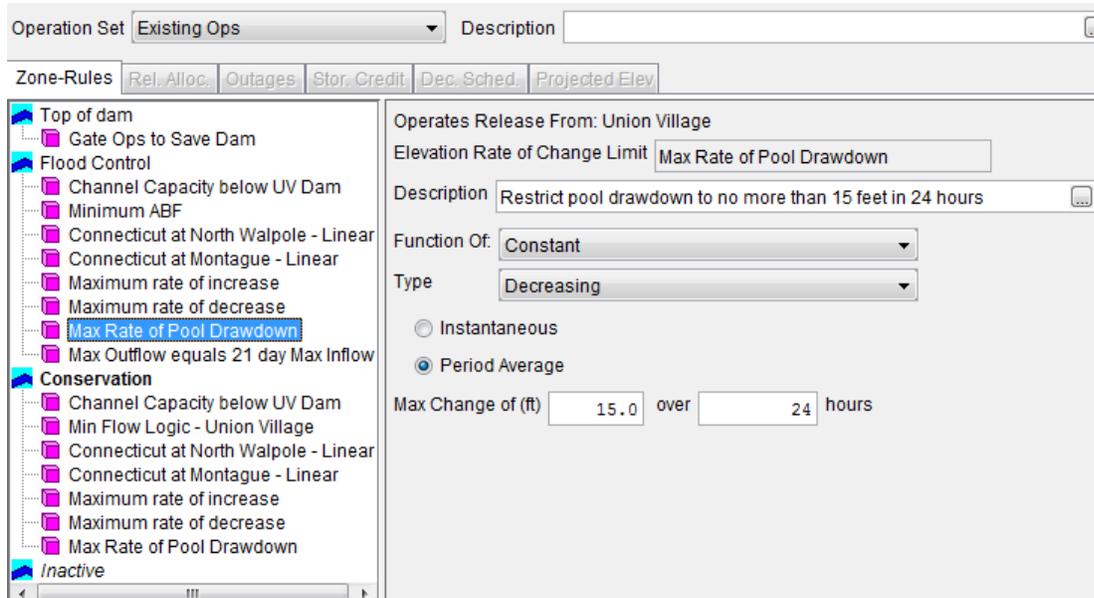


Figure 13 Reservoir Editor: Operations Tab – Existing Ops OpSet – Max Rate of pool Drawdown

### 9. Max Outflow equals 21 day Max Inflow

Figure 14 shows the content of “Max Outflow equals 21 day Max Inflow” rule. This rule represents the maximum release from dam as a function of the previous 3 weeks of inflow.

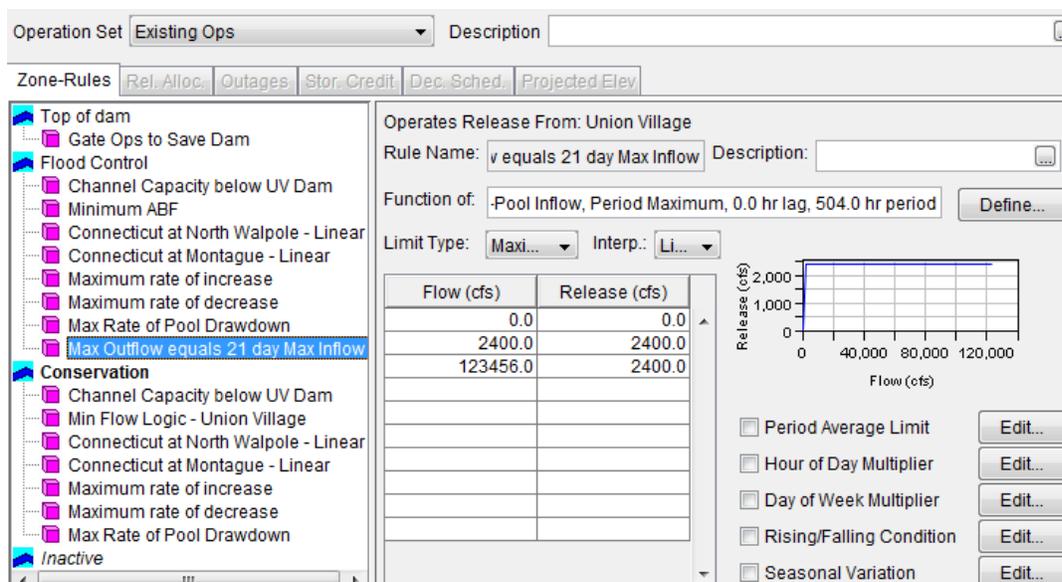


Figure 14 Reservoir Editor: Operations Tab – Existing Ops OpSet – Max Outflow equals 21 day Max Inflow

### 10. Min Flow Logic-Union Village

Figure 15 shows the content of “Min Flow Logic-Union Village” rule. This rule describes seasonal minimum flows from dam as a function of inflow at Union Village.

Operation Set: Existing Ops Description: [ ]

Zone-Rules: Rel. Alloc. Outages Stor. Credit Dec. Sched. **Projected Elev**

Operates Release From: Union Village

Rule Name: Flow Logic - Union Village Description: [ ]

Function of: Union Village-Pool Net Inflow, Current Value Define...

Limit Type: Minimum Interp.: Linear

| Flow (cfs) | Release (cfs) |         |        |        |
|------------|---------------|---------|--------|--------|
|            | 01Jan         | 01Apr   | 01Jun  | 01Oct  |
| 0.0        | 0.0           | 0.0     | 0.0    | 0.0    |
| 64.99      | 45.493        | 45.493  | 45.493 | 45.493 |
| 65.0       | 45.5          | 45.5    | 65.0   | 45.5   |
| 129.99     | 90.993        | 90.993  | 65.0   | 90.993 |
| 130.0      | 130.0         | 91.0    | 65.0   | 130.0  |
| 499.99     | 130.0         | 349.993 | 65.0   | 130.0  |
| 500.0      | 130.0         | 500.0   | 65.0   | 130.0  |
| 123456.0   | 130.0         | 500.0   | 65.0   | 130.0  |

Period Average Limit Edit...  
 Hour of Day Multiplier Edit...  
 Day of Week Multiplier Edit...  
 Rising/Falling Condition Edit...  
 Seasonal Variation Edit...

Figure 15 Reservoir Editor: Operations Tab – Existing Ops OpSet – Min Flow Logic-Union Village

# Upper Naukeag

## I. Overview

Upper Naukeag dam is located by the towns of Winchendon and Ashburnham, MA and feeds into the Millers River. The dam is owned and operated by the towns of Winchendon and Ashburnham and is used for water supply for the two towns.

Figure 1 shows the location of Upper Naukeag Dam as it is represented in the HEC-ResSim model. Figure 2 shows a photo of Upper Naukeag Lake.

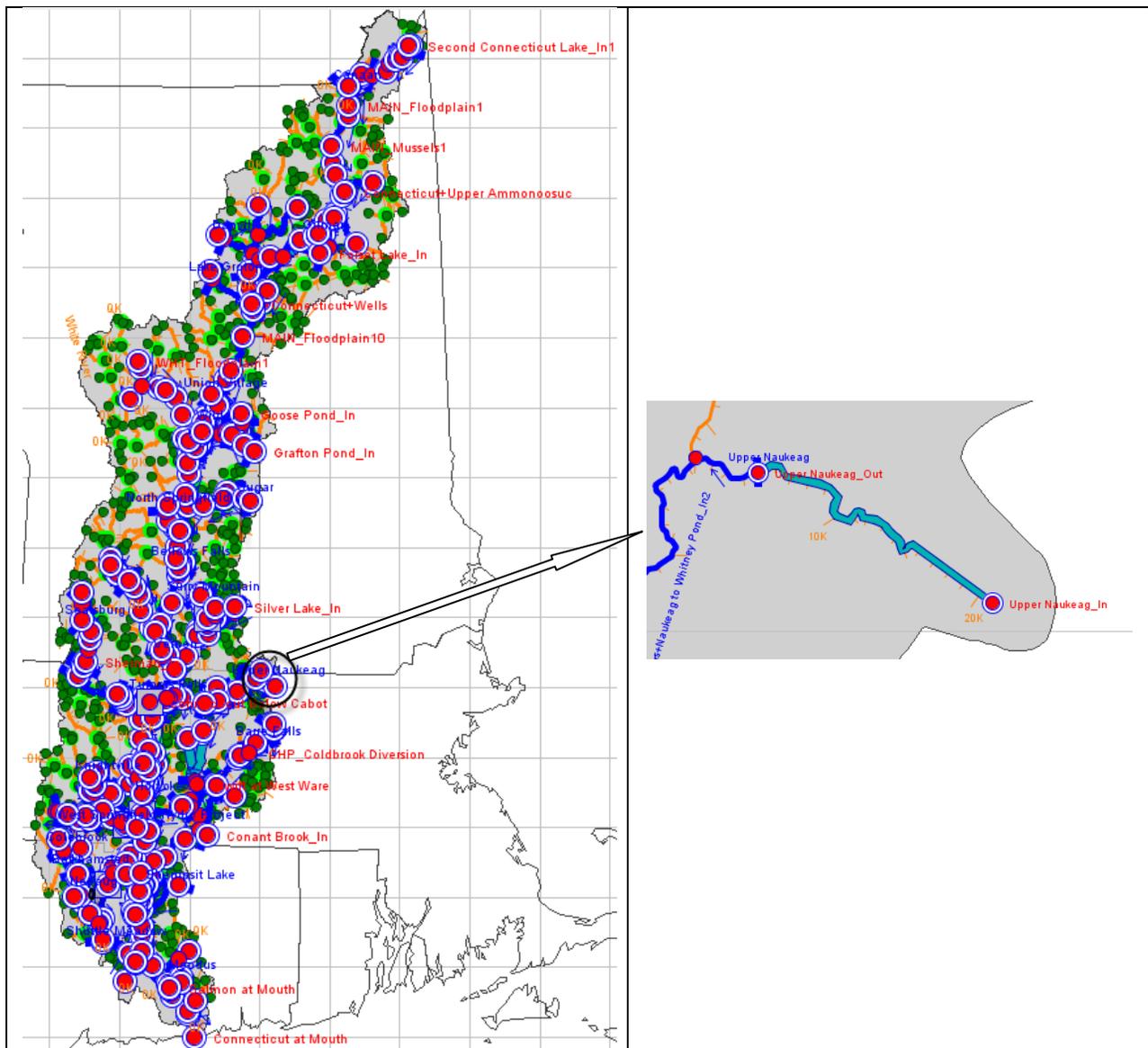


Figure 1: HEC-ResSim Map Display Showing Location of Upper Naukeag Dam



Figure 2: Photo of Upper Naukeag Lake.

## II. Physical Characteristics

The physical characteristics of the reservoir are separated between the Pool and the Dam in the HEC-ResSim model. The elevation-storage-area defines the pool as shown in Figure 3<sup>101</sup>. The dam consists of an uncontrolled outlet as shown in Figure 4.

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<sup>101</sup> National Inventory of Dams database.









**Figure 2: Photo of Vernon dam**

## **II. Physical Characteristics**

The physical characteristics of the reservoir are separated between the Pool and the Dam in the HEC-ResSim model. The elevation-storage-area defines the pool as shown in Figure 3<sup>103</sup>. The dam consists of nine types of outlets: (1) controlled Trash sluice gates, (2) controlled Tainter gates-10\*50, (3) controlled Tainter Gates-20\*50, (4) controlled sluice flood gate, (5) controlled Fish ladder, (6) uncontrolled stanchion 42.5 ft- W flashboards, (7) uncontrolled stanchion 50 ft-W flashboards, (8) controlled Fish Pipe+Fish Tube , and (9) power plant as shown in Figure 4.

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<sup>103</sup> Data provided by TransCanada

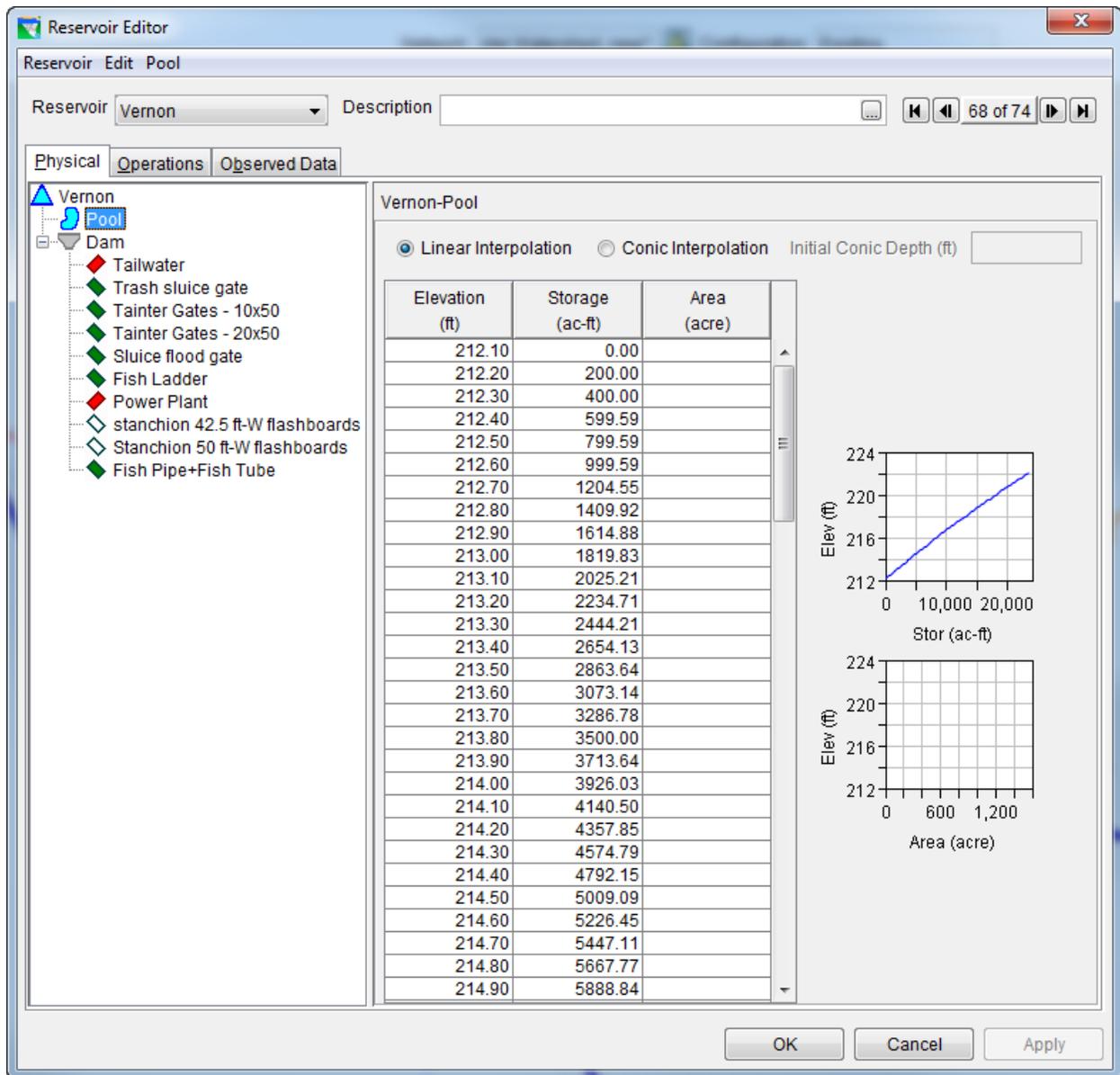


Figure 3: Reservoir Editor: Physical Tab -- Pool

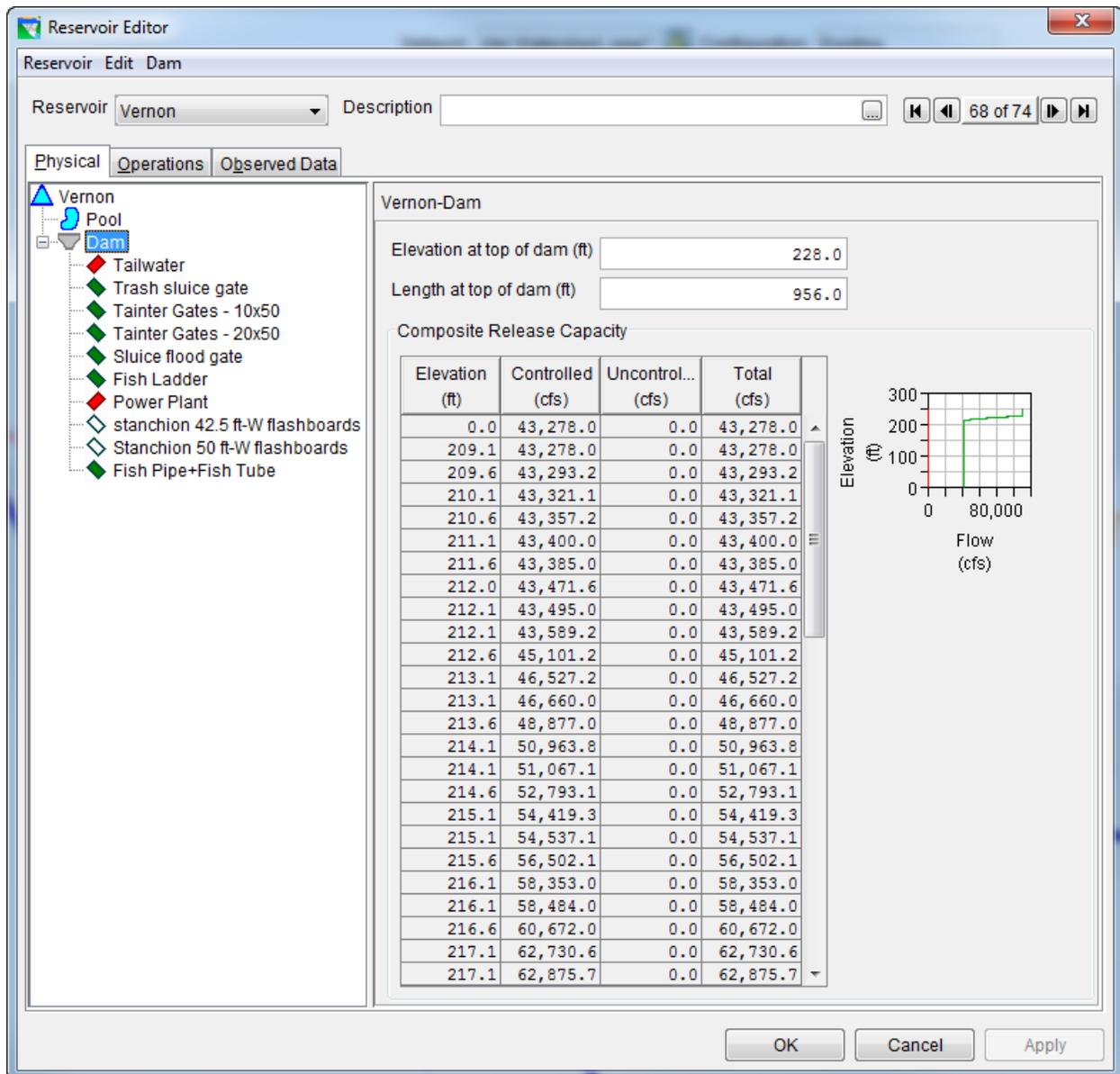


Figure 4: Reservoir Editor: Physical Tab -- Dam



## B. Rule Illustrations

Figure 6 shows a set of operational rules specified for each zone that reflects the operation set named Existing Ops<sup>104</sup>.

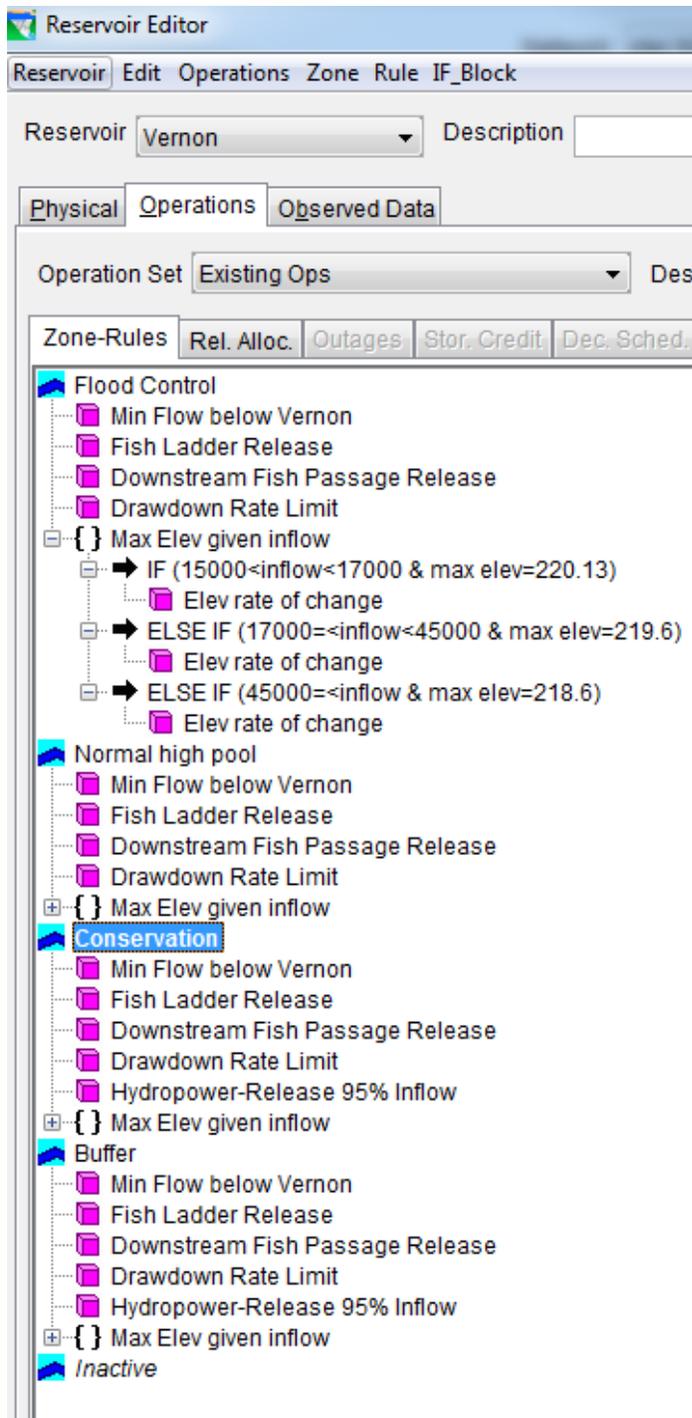


Figure 6: Reservoir Editor: Operations Tab – Existing Ops OpSet – Zones and Rules

<sup>104</sup> TransCanada. Connecticut River Operational Constraints. 2012.

Figure 7 shows a sequential release allocation approach specified for available outlets along Bellows Falls Dam. The available outlets are given an order of priority for release. The power plant gets the release first until it reaches release capacity. The Trash sluice gate gets the remainder of the release until it reaches capacity. The flow passes through Tainter Gates-10\*50 and then Tainter Gates-20\*50. The next priority is assigned to sluice flood gate. After the capacity through the sluice flood gate is reached, the remainder of the release goes through the Fish pipe+Fish Tube and Fish Ladder, respectively.

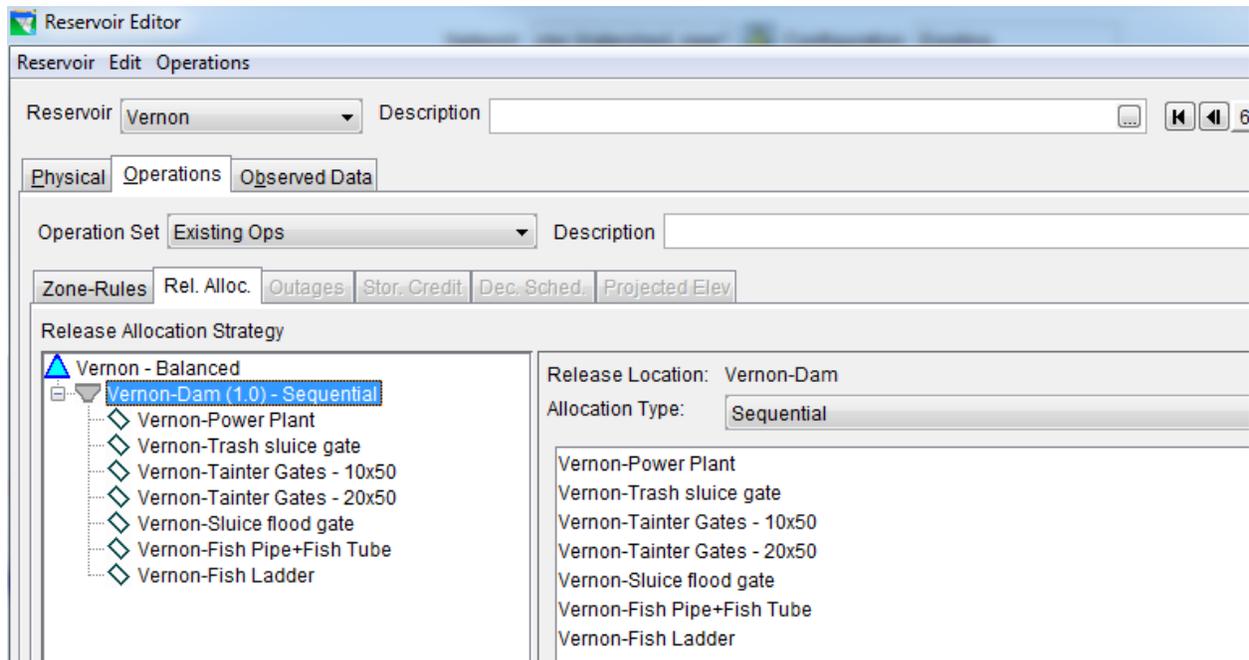


Figure 7: Reservoir Editor: Operations Tab – Existing Ops OpSet – Release Allocation

## C. Rule Descriptions

### 1. Min Flow below Vernon

Figure 8 shows the content of “Min flow below Vernon” rule. This rule shows a minimum release from dam as a function of Inflow.

The screenshot shows the 'Operations Tab' in the 'Existing Ops OpSet'. The 'Min Flow below Vernon' rule is selected in the tree view. The configuration panel shows the rule name and description, the function 'Vernon-Pool Net Inflow, Current Value', and a limit type of 'Min...'. A table shows the relationship between flow and release, and a graph plots release against flow.

| Flow (cfs) | Release (cfs) |
|------------|---------------|
| 0.0        | 0.0           |
| 1250.0     | 1250.0        |
| 500000.0   | 1250.0        |

The graph shows a horizontal line at a release of 1,200 cfs for flow values greater than 1,250 cfs. The y-axis is labeled 'Release (cfs)' and ranges from 0 to 1,200. The x-axis is labeled 'Flow (cfs)' and ranges from 0 to 400,000.

Figure 8: Reservoir Editor: Operations Tab – Existing Ops OpSet – Min Flow below Vernon





#### 4. Drawdown Rate Limit

Figure 11 shows the content of “Drawdown Rate Limit” rule. This rule shows the decreasing elevation rate of change rule.

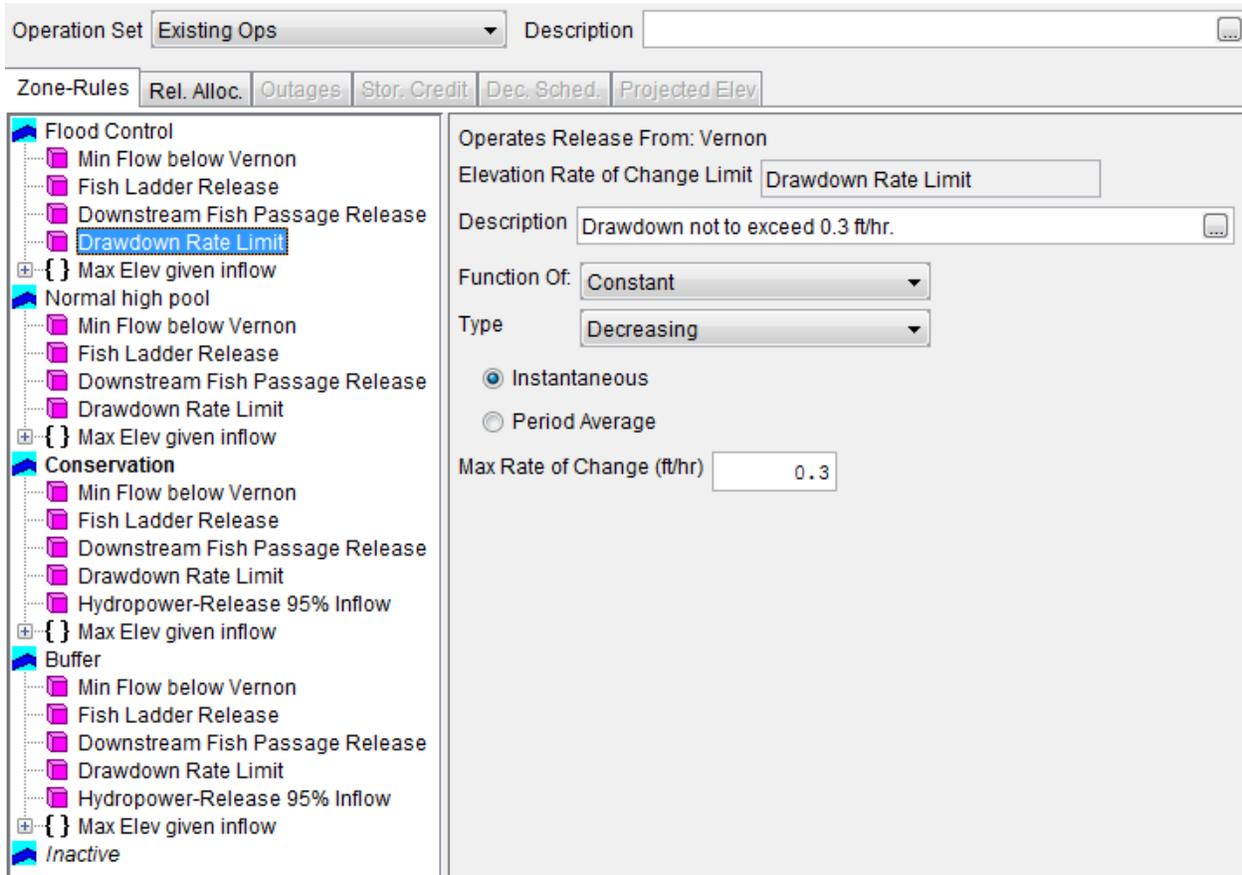


Figure 11: Reservoir Editor: Operations Tab – Existing Ops OpSet – Drawdown Rate Limit

### 5. Max Elev given inflow

Figure 12 shows the content of “Max Elev given inflow” rule. For each combination of Inflow and maximum pool elevation shown in the below picture the maximum elevation rate of change equals zero.

The figure consists of three screenshots of a software interface, likely for dam operations, showing the configuration of a rule named "Max Elev given inflow".

**Top Screenshot:** Shows the rule configuration in the "Zone-Rules" tab. The rule is selected in a tree view under "Flood Control". The right pane shows the rule details: "Operates Release From: Vernon-Power Plant", Name: "Max Elev given inflow", and a table of conditions.

| Type    | Name                             | Description |
|---------|----------------------------------|-------------|
| IF      | 15000<inflow<17000 & max elev... |             |
| ELSE IF | 17000=<inflow<45000 & max ele... |             |
| ELSE IF | 45000=<inflow & max elev=218.6   |             |

**Middle Screenshot:** Shows the "IF Conditional" configuration for the first rule condition. The conditional is "17000 & max elev=220.13". The right pane shows a table for defining the conditional logic.

|     | Value1                 |    | Value2 |
|-----|------------------------|----|--------|
|     | Vernon-Pool:Net Inflow | >  | 15000  |
| AND | Vernon-Pool:Net Inflow | <  | 17000  |
| AND | Vernon-Pool:Elevation  | >= | 220.13 |

**Bottom Screenshot:** Shows the "Elev rate of change" configuration for the selected rule. The right pane shows "Operates Release From: Vernon", "Elevation Rate of Change Limit: Elev rate of change", "Function Of: Constant", "Type: Increasing", and "Max Rate of Change (ft/hr): 0.0".

Operation Set Existing Ops Description

Zone-Rules Rel. Alloc. Outages Stor. Credit Dec. Sched. Projected Elev

Flood Control

- Min Flow below Vernon
- Fish Ladder Release
- Downstream Fish Passage Release
- Drawdown Rate Limit
- Max Elev given inflow
  - IF (15000<inflow<17000 & max elev=220.13)
    - Elev rate of change
  - ELSE IF (17000=<inflow<45000 & max elev=219.6)
    - Elev rate of change
  - ELSE IF (45000=<inflow & max elev=218.6)
    - Elev rate of change
- Normal high pool
- Min Flow below Vernon

Operates Release From: Vernon

ELSE IF Conditional <45000 & max elev=219.6 Description:

|     | Value1                 |    | Value2 |
|-----|------------------------|----|--------|
|     | Vernon-Pool:Net Inflow | >= | 17000  |
| AND | Vernon-Pool:Net Inflow | <  | 45000  |
| AND | Vernon-Pool:Elevation  | >= | 219.6  |

Add Cond. Del. Cond.

---

Operation Set Existing Ops Description

Zone-Rules Rel. Alloc. Outages Stor. Credit Dec. Sched. Projected Elev

Flood Control

- Min Flow below Vernon
- Fish Ladder Release
- Downstream Fish Passage Release
- Drawdown Rate Limit
- Max Elev given inflow
  - IF (15000<inflow<17000 & max elev=220.13)
    - Elev rate of change
  - ELSE IF (17000=<inflow<45000 & max elev=219.6)
    - Elev rate of change
  - ELSE IF (45000=<inflow & max elev=218.6)
    - Elev rate of change
- Normal high pool
- Min Flow below Vernon

Operates Release From: Vernon

Elevation Rate of Change Limit Elev rate of change

Description

Function Of: Constant

Type Increasing

Instantaneous  
 Period Average

Max Rate of Change (ft/hr) 0.0

---

Operation Set Existing Ops Description

Zone-Rules Rel. Alloc. Outages Stor. Credit Dec. Sched. Projected Elev

Flood Control

- Min Flow below Vernon
- Fish Ladder Release
- Downstream Fish Passage Release
- Drawdown Rate Limit
- Max Elev given inflow
  - IF (15000<inflow<17000 & max elev=220.13)
    - Elev rate of change
  - ELSE IF (17000=<inflow<45000 & max elev=219.6)
    - Elev rate of change
  - ELSE IF (45000=<inflow & max elev=218.6)
    - Elev rate of change
- Normal high pool
- Min Flow below Vernon

Operates Release From: Vernon

ELSE IF Conditional =<inflow & max elev=218.6 Description:

|     | Value1                 |    | Value2 |
|-----|------------------------|----|--------|
|     | Vernon-Pool:Net Inflow | >= | 45000  |
| AND | Vernon-Pool:Elevation  | >= | 218.6  |

Add Cond. Del. Cond.

---

Operation Set Existing Ops Description

Zone-Rules Rel. Alloc. Outages Stor. Credit Dec. Sched. Projected Elev

Flood Control

- Min Flow below Vernon
- Fish Ladder Release
- Downstream Fish Passage Release
- Drawdown Rate Limit
- Max Elev given inflow
  - IF (15000<inflow<17000 & max elev=220.13)
    - Elev rate of change
  - ELSE IF (17000=<inflow<45000 & max elev=219.6)
    - Elev rate of change
  - ELSE IF (45000=<inflow & max elev=218.6)
    - Elev rate of change
- Normal high pool
- Min Flow below Vernon

Operates Release From: Vernon

Elevation Rate of Change Limit Elev rate of change

Description

Function Of: Constant

Type Increasing

Instantaneous  
 Period Average

Max Rate of Change (ft/hr) 0.0

Figure 12: Reservoir Editor: Operations Tab – Existing Ops OpSet – Max Elev given inflow

### 6. Hydropower-Release 95% Inflow

Figure 13 shows the content of “Hydropower-Release 95% Inflow” rule. This rule passes 95% of Inflow through power plant as per the run-of-river modeling strategy.

The screenshot displays the 'Operations Tab' in the Reservoir Editor. The 'Existing Ops' operation set is selected. The 'Hydropower-Release 95% Inflow' rule is highlighted in the tree view. The configuration panel for this rule shows the following details:

- Operates Release From:** Vernon-Power Plant
- Rule Name:** lower-Release 95% Inflow
- Function of:** Vernon-Pool Net Inflow, Current Value
- Limit Type:** Minim... (Minimum)
- Interp.:** Li... (Linear)

The graph shows a linear relationship between Flow (cfs) on the x-axis and Release (cfs) on the y-axis. The x-axis ranges from 0 to 100,000 cfs, and the y-axis ranges from 0 to 100,000 cfs. A blue line starts at (0, 0) and ends at (100,000, 95,000), representing a 95% release rate.

| Flow (cfs) | Release (cfs) |
|------------|---------------|
| 0.0        | 0.0           |
| 100000.0   | 95000.0       |

Figure 13: Reservoir Editor: Operations Tab – Existing Ops OpSet – Hydropower-Release 95% Inflow

## Ware Upper and Lower

### I. Overview

Ware Upper and Lower are two dams located in Ware, MA on the Ware River. It is owned and operated by Ware River Hydroelectric Company and is used to generate hydropower.

Figure 1 shows the location of Ware upper and lower dam as it is represented in the HEC-ResSim model. Figure 2 shows a photo of Ware upper dam.

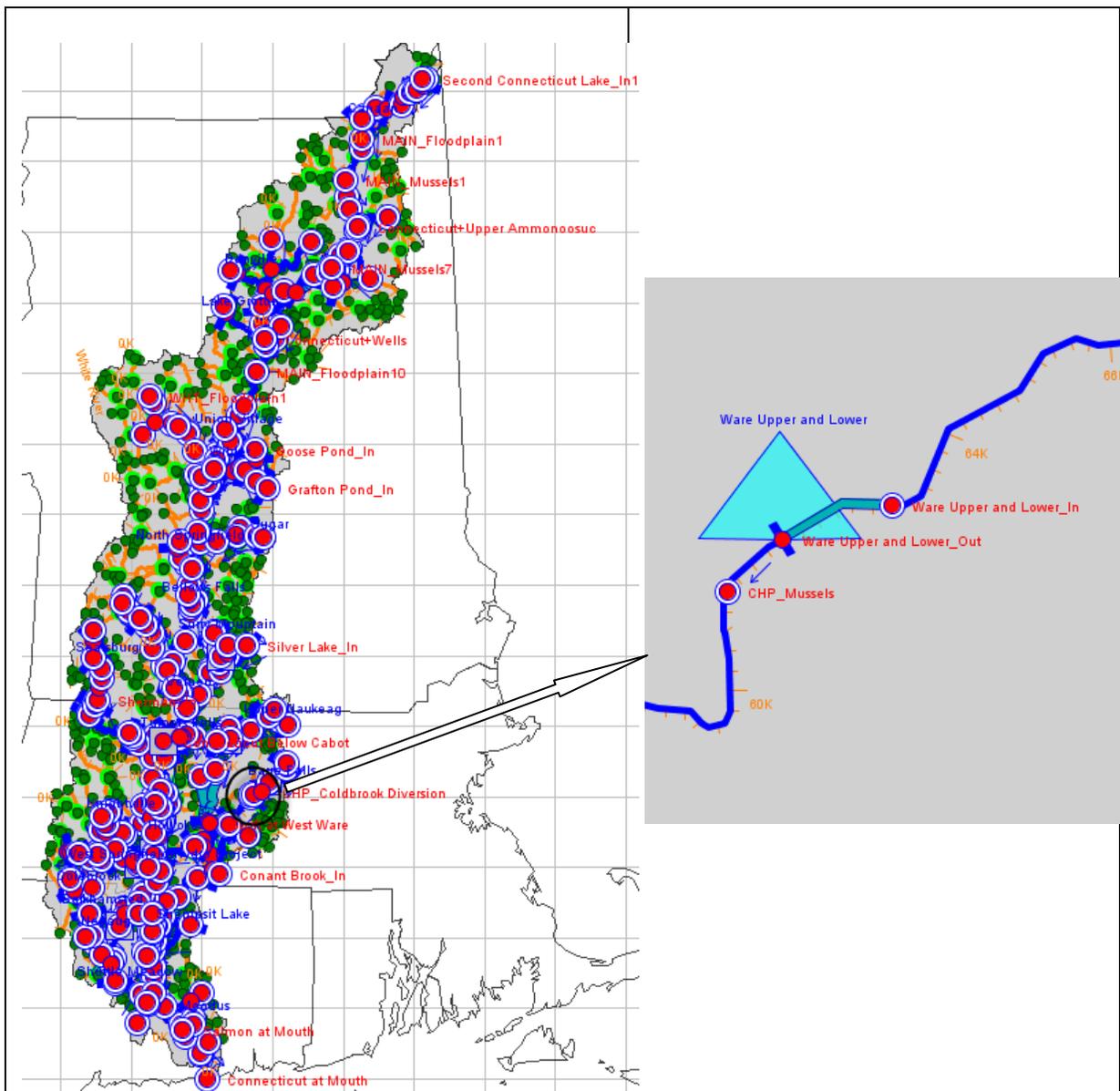
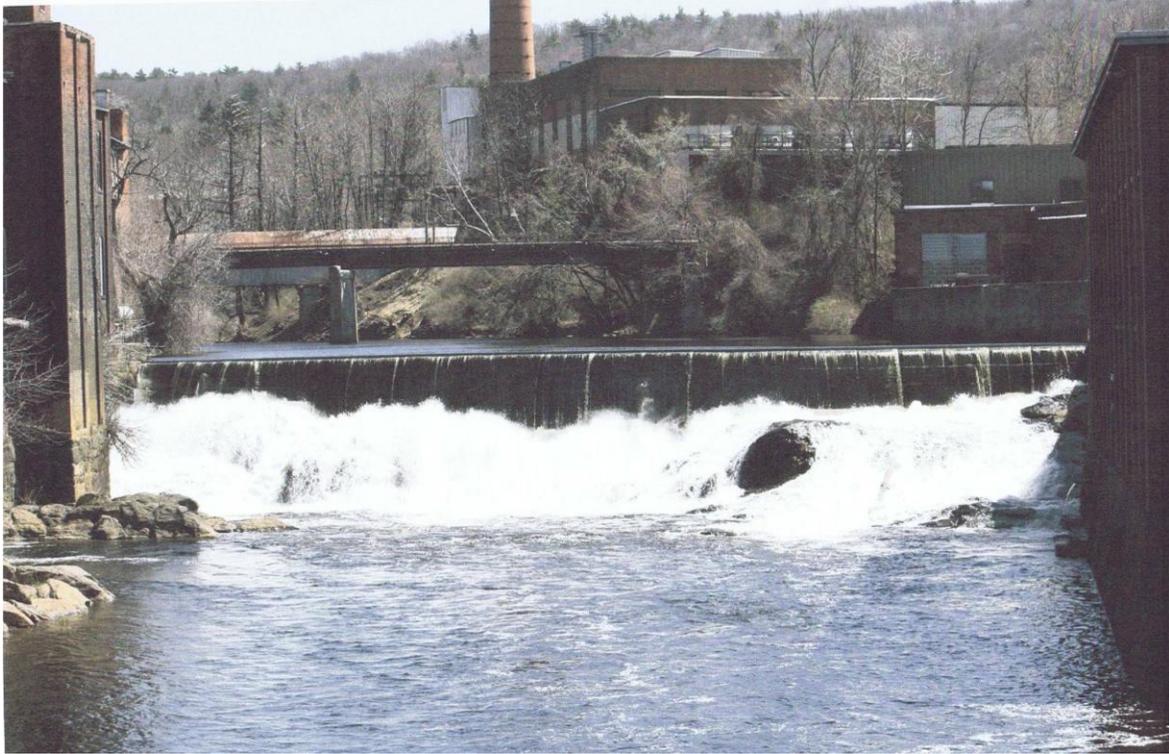


Figure 1: HEC-ResSim Map Display Showing Location of Ware upper and lower Dam



**Figure 2: Photo of Ware upper dam**

## **II. Physical Characteristics**

The physical characteristics of the reservoir are separated between the Pool and the Dam in the HEC-ResSim model. The elevation-storage-area defines the pool as shown in Figure 3<sup>105</sup>. The dam consists of two types of outlets: (1) uncontrolled outlet and (3) power plant as shown in Figure 4<sup>1,106</sup>. The capacity of the power plant was made to be the maximum release specified in the NID database so that the dam would modeled completely as run-of-river with some actual physical information.

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<sup>105</sup> National Inventory of Dams database (NID)

<sup>106</sup> <http://www.lowimpacthydro.org.php5-11.dfw1-2.websitetestlink.com/lihi-certificate-47-ware-river-hydroelectric-company-project-ferc-no.-3127-ware-river-massachusetts.html>





# West Branch

## I. Overview

West Branch dam (known as Goodwin Dam) is located directly downstream of Colebrook dam on the Farmington River in Hartland, CT. It is owned and operated by The Metropolitan Water District of Hartford, CT (MDC) and is used for drinking water supply and some recreation.

Figure 1 shows the location of West Branch as it is represented in the HEC-ResSim model, and Figure 2 shows a photo for West Branch.

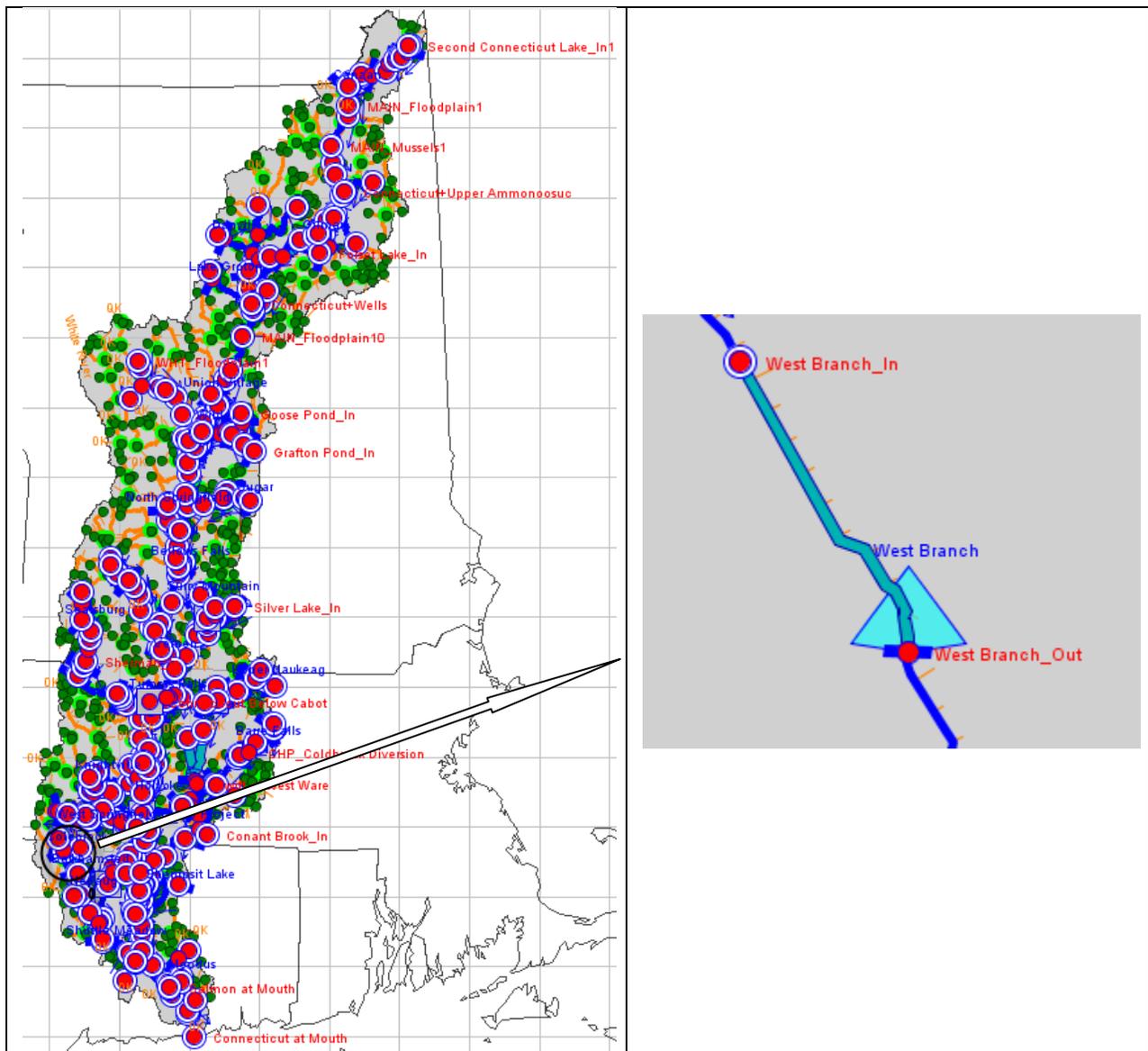


Figure 1: HEC-ResSim Map Display Showing Location of West Branch



Figure 2: Photo of West Branch dam

## II. Physical Characteristics

The physical characteristics of the reservoir are separated between the Pool and the Dam in the HEC-ResSim model. The elevation-storage-area defines the pool as shown in Figure 3<sup>107</sup>. The dam consists of a controlled outlet as shown in Figure 4<sup>108</sup>.

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<sup>107</sup> MDC 1999

<sup>108</sup> Data from UMASS

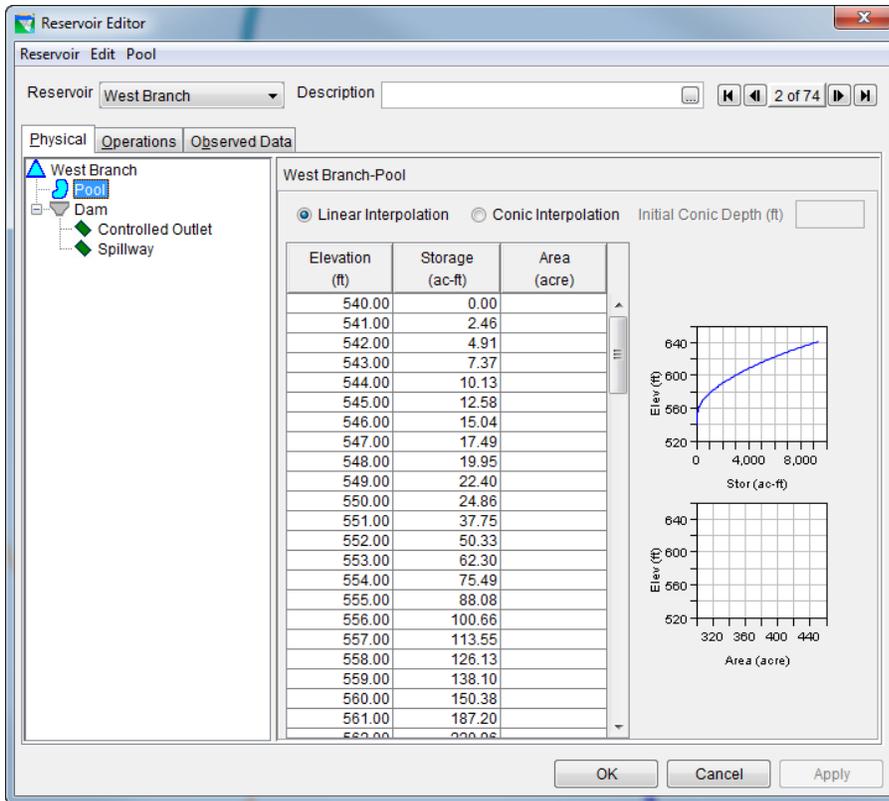


Figure 3: Reservoir Editor: Physical Tab -- Pool

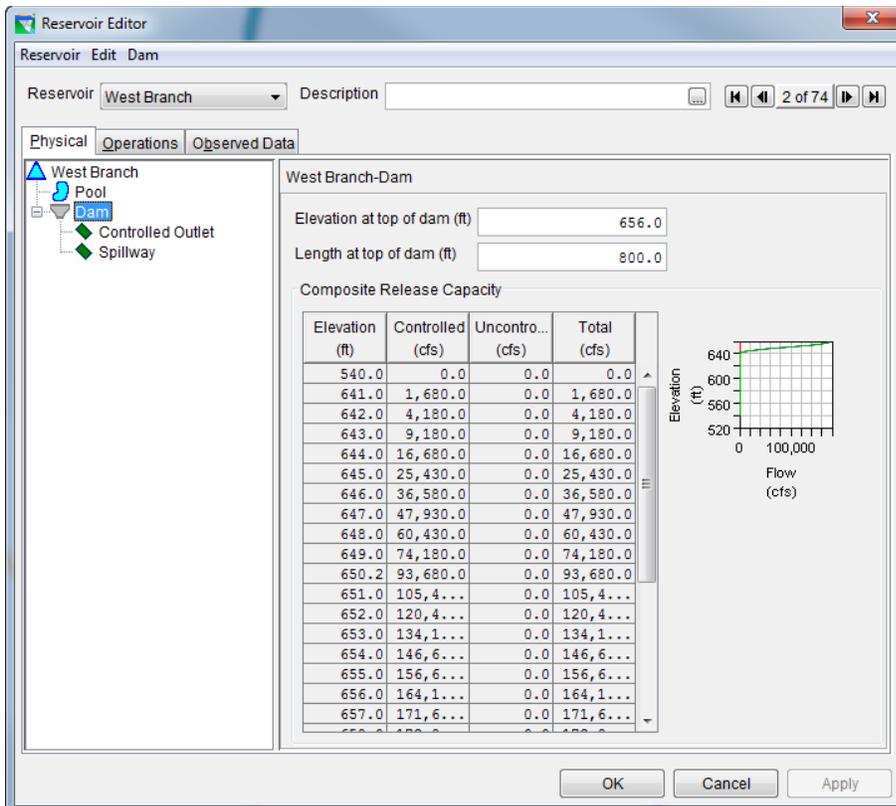


Figure 4: Reservoir Editor: Physical Tab -- Dam



## West Springfield Hydro Project

### I. Overview

West Springfield is dam located in West Springfield, MA on the Westfield River. It is owned and operated by A&D Hydro, Inc and is used for hydropower generation.

Figure 1 shows the location of West Springfield dam as it is represented in the HEC-ResSim model. Figure 2 shows a photo of West Springfield dam.

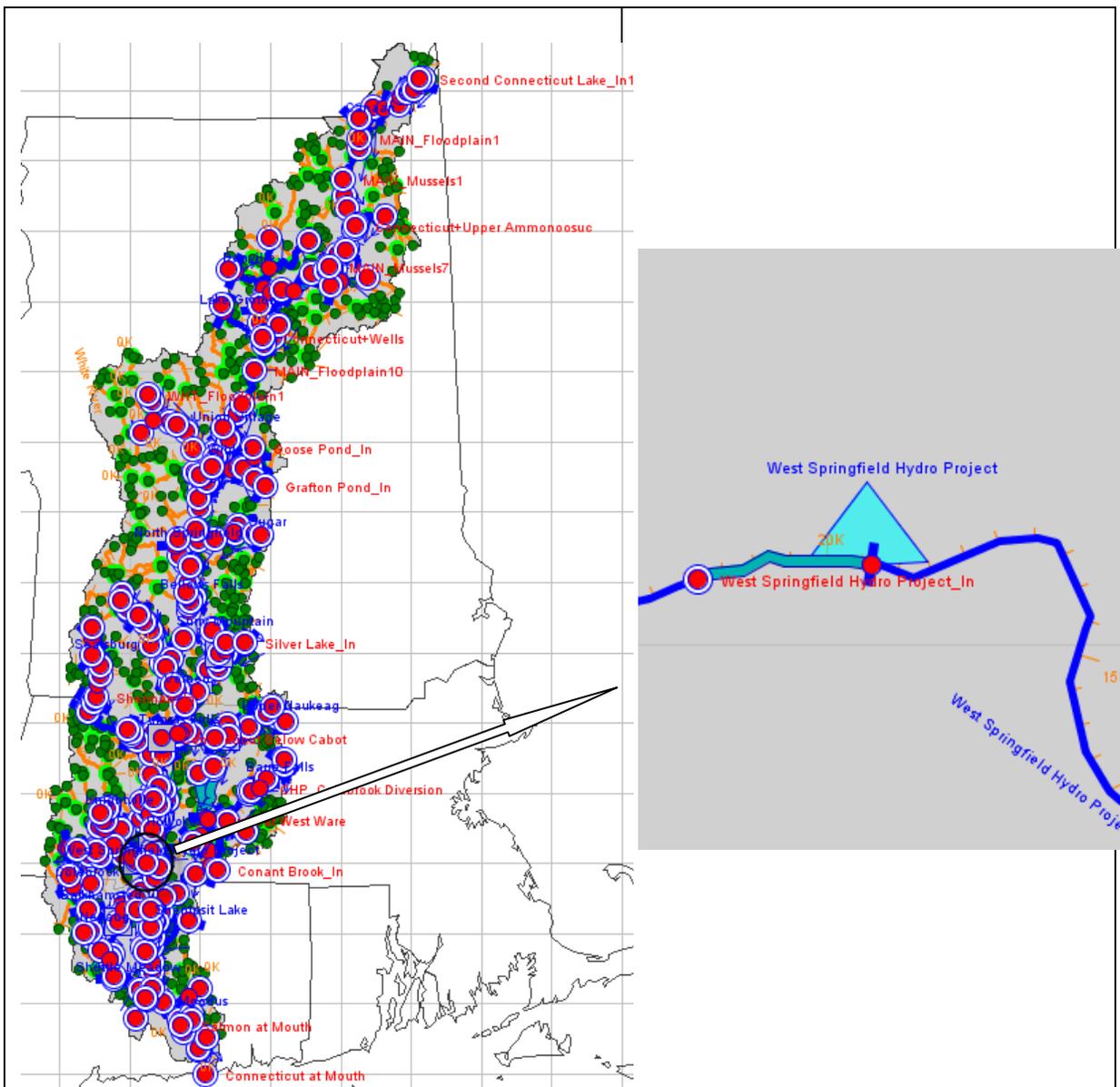


Figure 1: HEC-ResSim Map Display Showing Location of West Springfield Dam



Figure 2: Photo of West Springfield dam

## II. Physical Characteristics

The physical characteristics of the reservoir are separated between the Pool and the Dam in the HEC-ResSim model. The elevation-storage-area defines the pool as shown in Figure 3<sup>109</sup>. The dam consists of two types of outlets: (1) uncontrolled outlet and (3) power plant as shown in Figure 4<sup>110</sup>. The capacity of the power plant was made to be the maximum release specified in the NID database so that the dam would modeled completely as run-of-river with some actual physical information.

<sup>109</sup> National Inventory of Dams database (NID)

<sup>110</sup> <http://www.lowimpacthydro.org/lihi-certificate-19-west-springfield-project-westfield-river-west-springfield-agawam-ma.-ferc-2608.html>



### III. Operations

#### A. Operation Set

Zones are used to define the operational storage in the reservoir to determine the reservoir release through analysis of the rules contained within each zone. Figure 5 shows the definition of West Springfield’s “Guide Curve” operational zones, which consist of Flood Control (18 ft), Conservation (17.9 ft), and Inactive zone (8 ft)<sup>1</sup>. There was no specified inactive zone so 10 feet below top of dam was arbitrarily chosen.

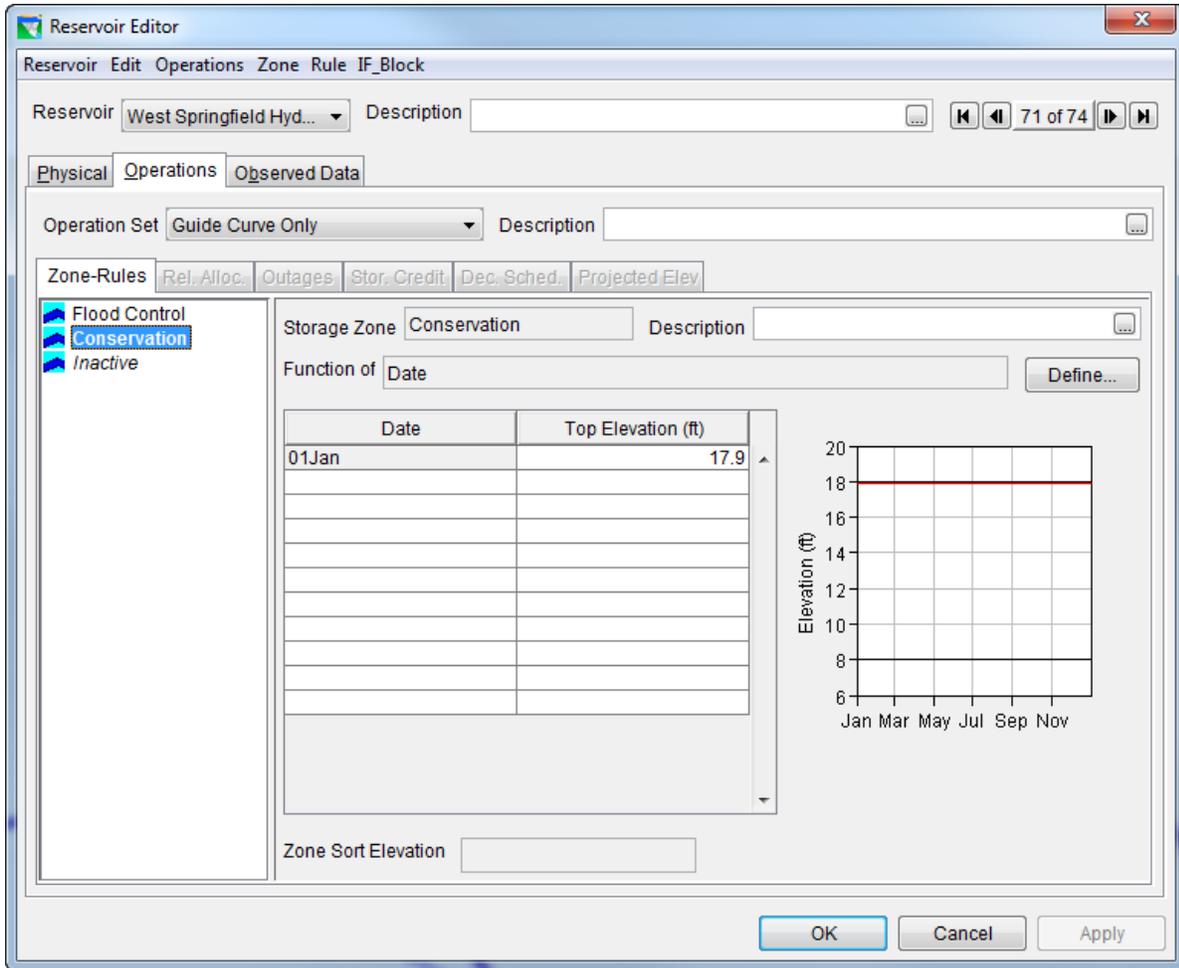


Figure 5: Reservoir Editor: Operations Tab –Guide Curve OpSet – Guide Curve

#### B. Rule Illustrations

The operation set for West Springfield has no rules of operation making it a flow through reservoir. The pool elevation will remain at the top of conservation unless the inflow exceeds the total release capacity. This was modeled this way because no real operation information was found.





Figure 2: Photo of Whitney Pond

## II. Physical Characteristics

The physical characteristics of the reservoir are separated between the Pool and the Dam in the HEC-ResSim model. The elevation-storage-area defines the pool as shown in Figure 3<sup>111</sup>. The dam consists of two types of outlets: (1) an uncontrolled Outlet and an uncontrolled flow over embankment as shown in Figure 4.

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<sup>111</sup> Phase I National Dam Inspection Program. 1979.

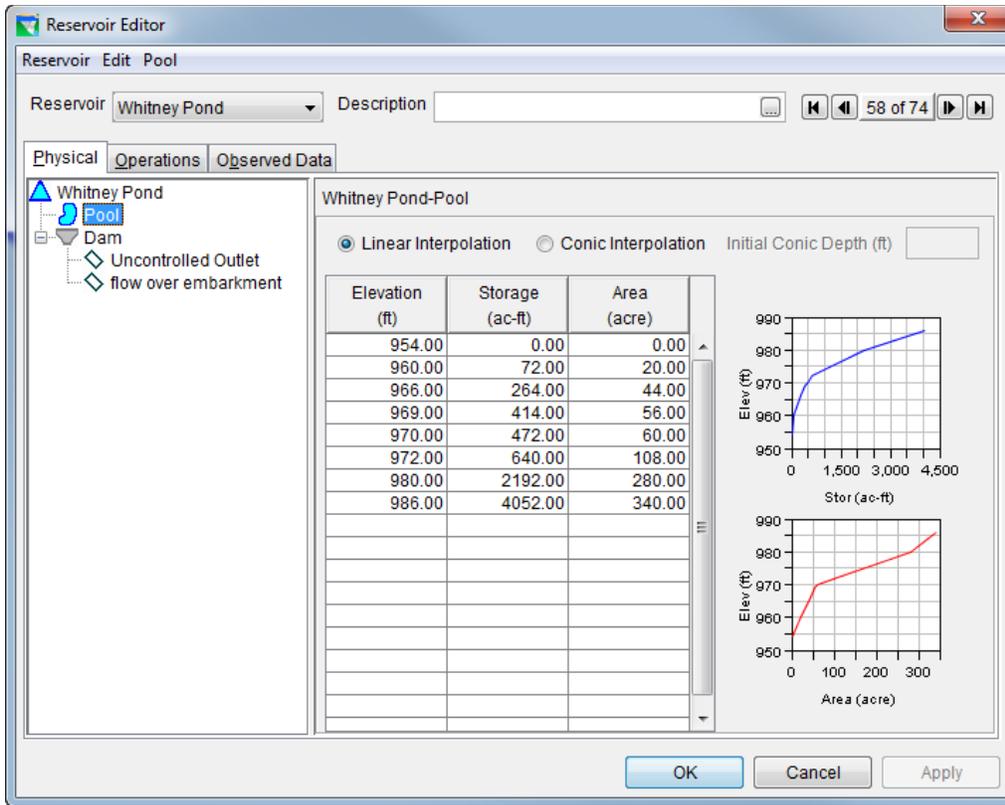


Figure 3: Reservoir Editor: Physical Tab -- Pool

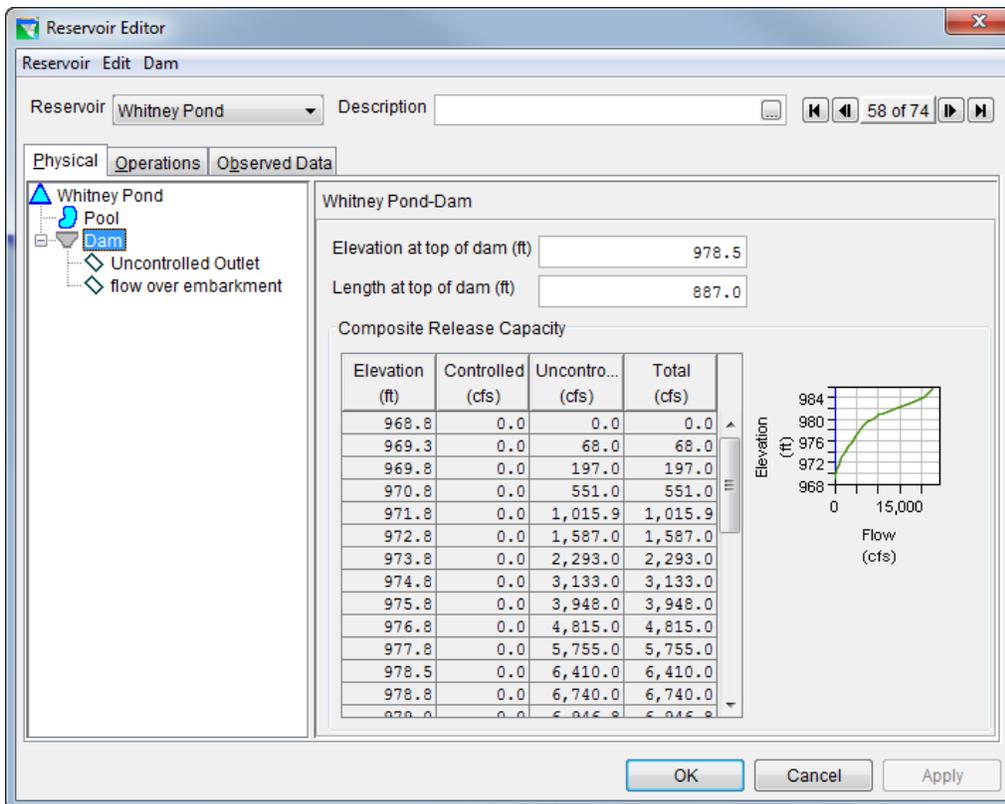


Figure 4: Reservoir Editor: Physical Tab -- Dam

### III. Operations

#### A. Operation Set

Zones are used to define the operational storage in the reservoir to determine the reservoir release through analysis of the rules contained within each zone. Figure 5 shows the definition of Whitney Pond Dam's "Guide Curve" operational zones, which consist of zones of Top of Dam (978.5 ft), Flood Control (970 ft), Conservation (968.8 ft), and Inactive zone (955 ft)<sup>1</sup>.

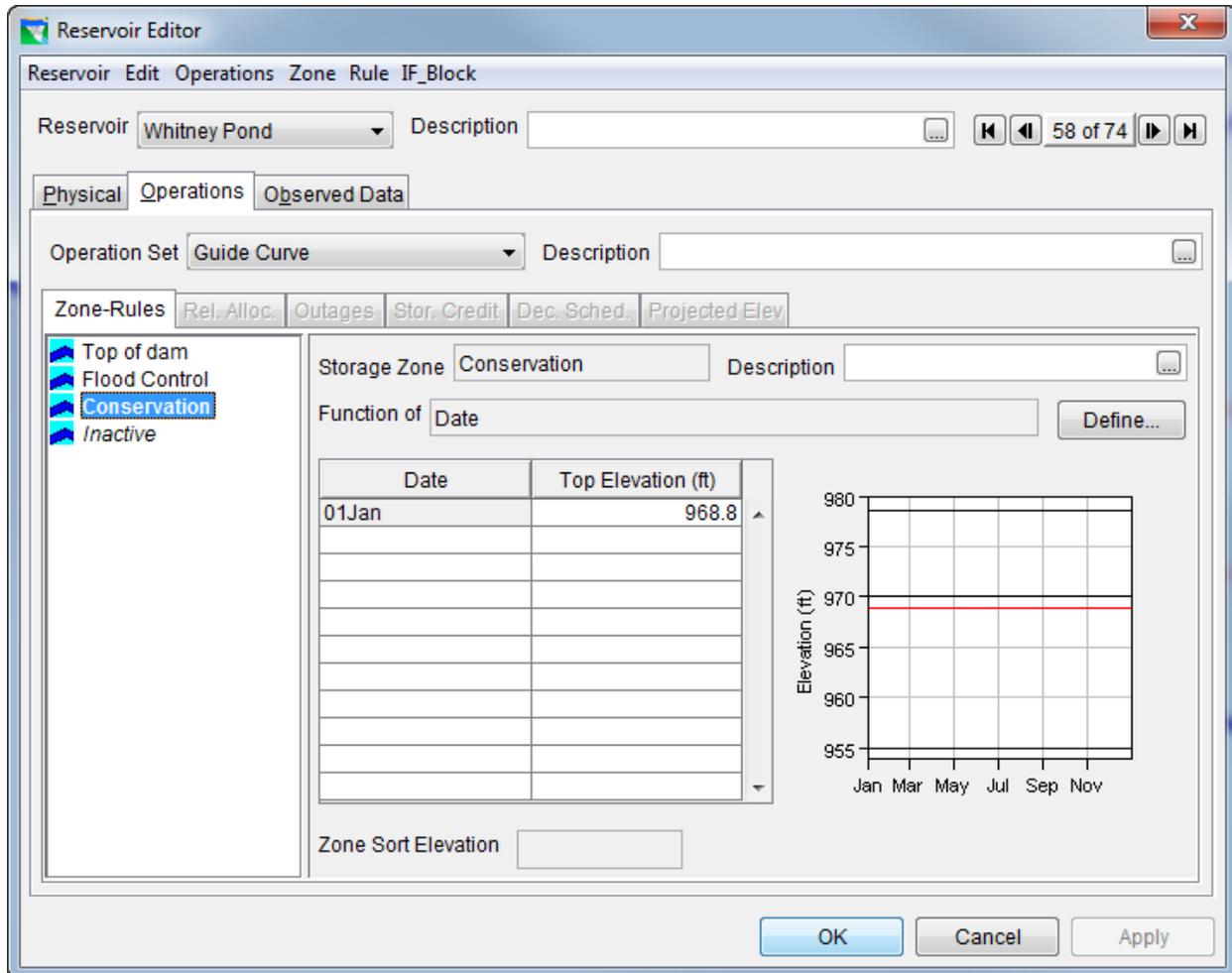


Figure 5: Reservoir Editor: Operations Tab – Guide Curve OpSet

#### B. Rule Illustrations

The operation set for Whitney Pond Dam has no rules of operation making it a flow through reservoir. The pool elevation will remain at the top of conservation unless the inflow exceeds the total release capacity.

# Wilder

## I. Overview

Wilder dam is located in the town of Wilder, VT on the mainstem Connecticut River. It is owned and operated by TransCanada Hydro Northeast Inc. for hydropower generation.

Figure 1 shows the location of Wilder Dam as it is represented in the HEC-ResSim model, and Figure 2 shows a photo from Wilder dam.

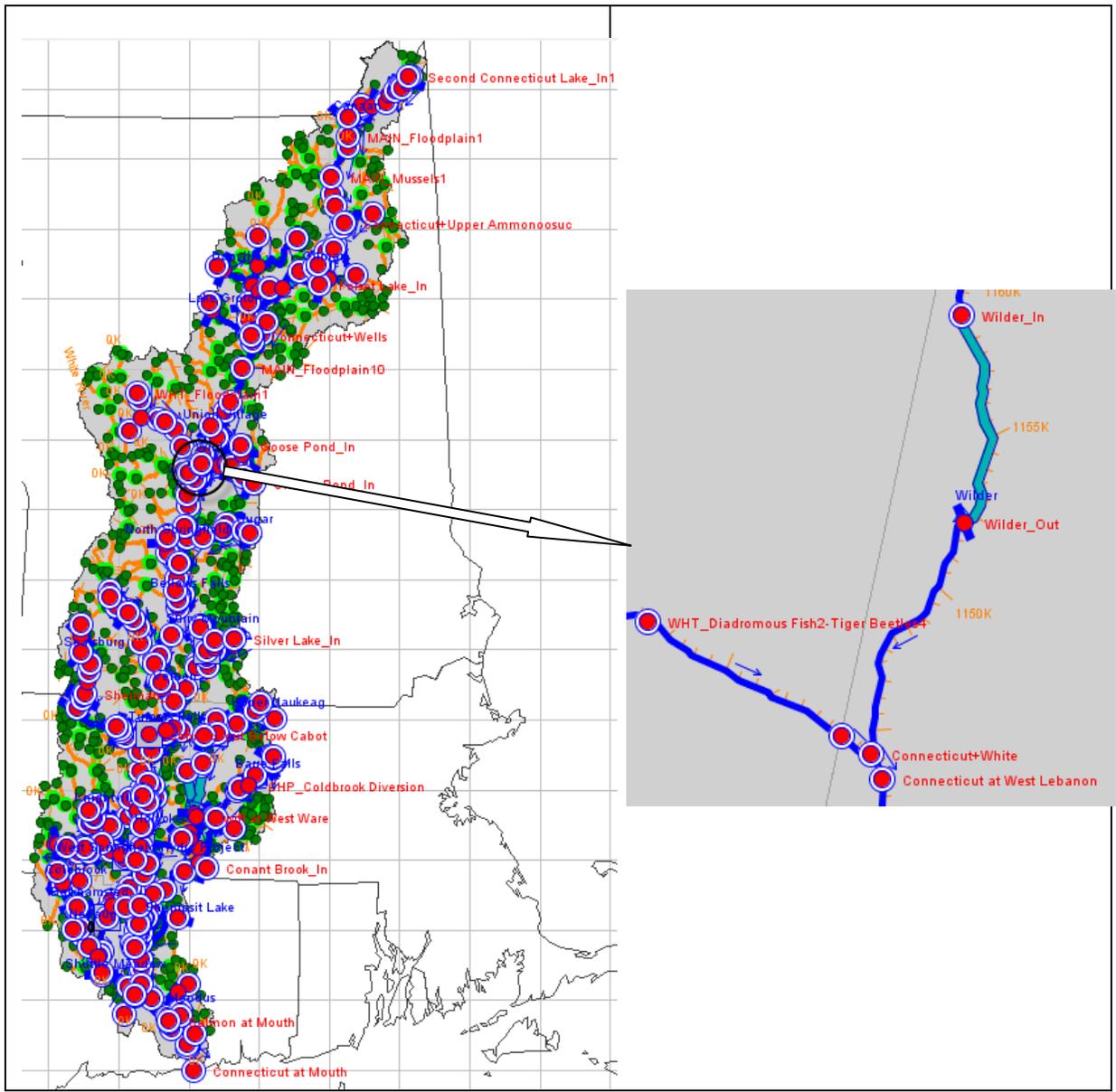


Figure 1: HEC-ResSim Map Display Showing Location of Wilder dam

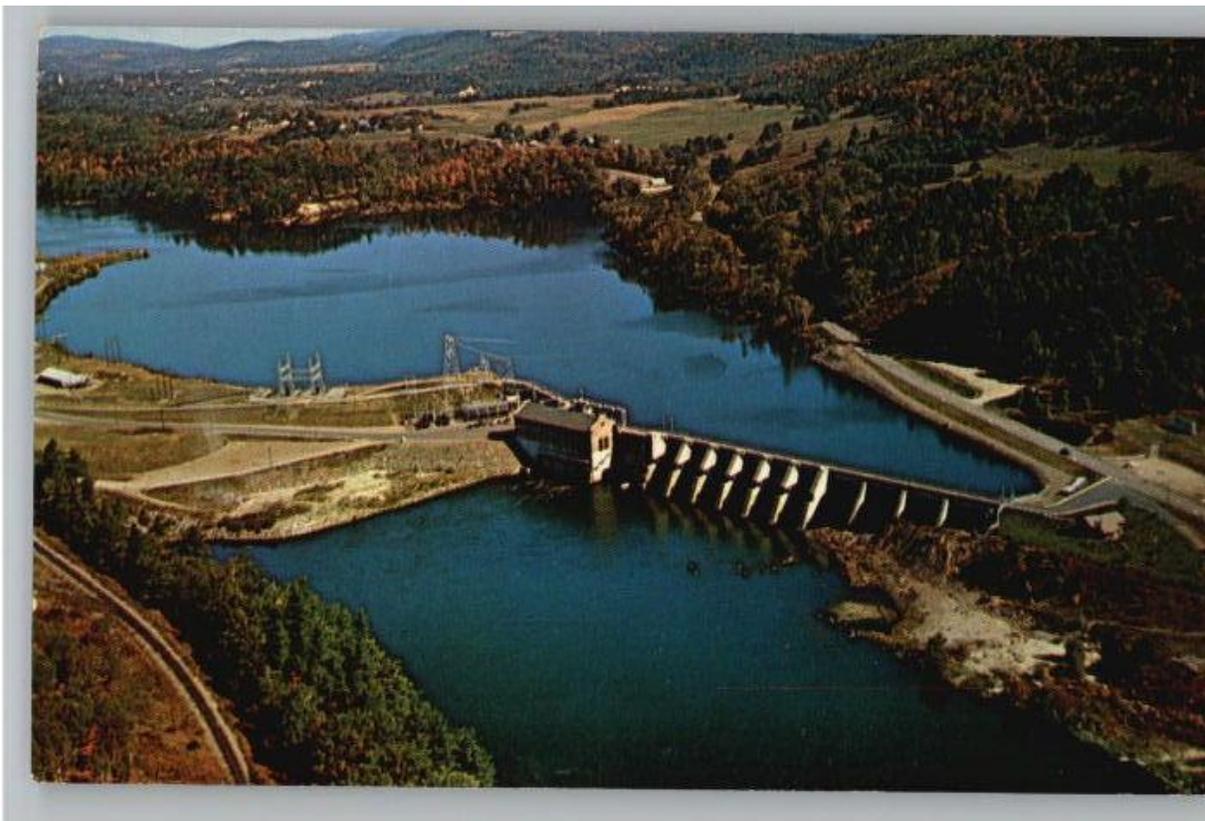


Figure 2: Photo of Wilder dam

## II. Physical Characteristics

The physical characteristics of the reservoir are separated between the Pool and the Dam in the HEC-ResSim model. The elevation-storage-area defines the pool as shown in Figure 3<sup>112</sup>. The dam consists of six types of outlets: (1) controlled Tainter gates, (2) controlled skimmer gate 10\*10 ft, (3) controlled skimmer gate 15\*20 ft, (4) controlled Fish Ladder, (5) uncontrolled stanchion-stoplogs in, and (6) power plant as shown in Figure 4.

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<sup>112</sup> Data provided by TransCanada

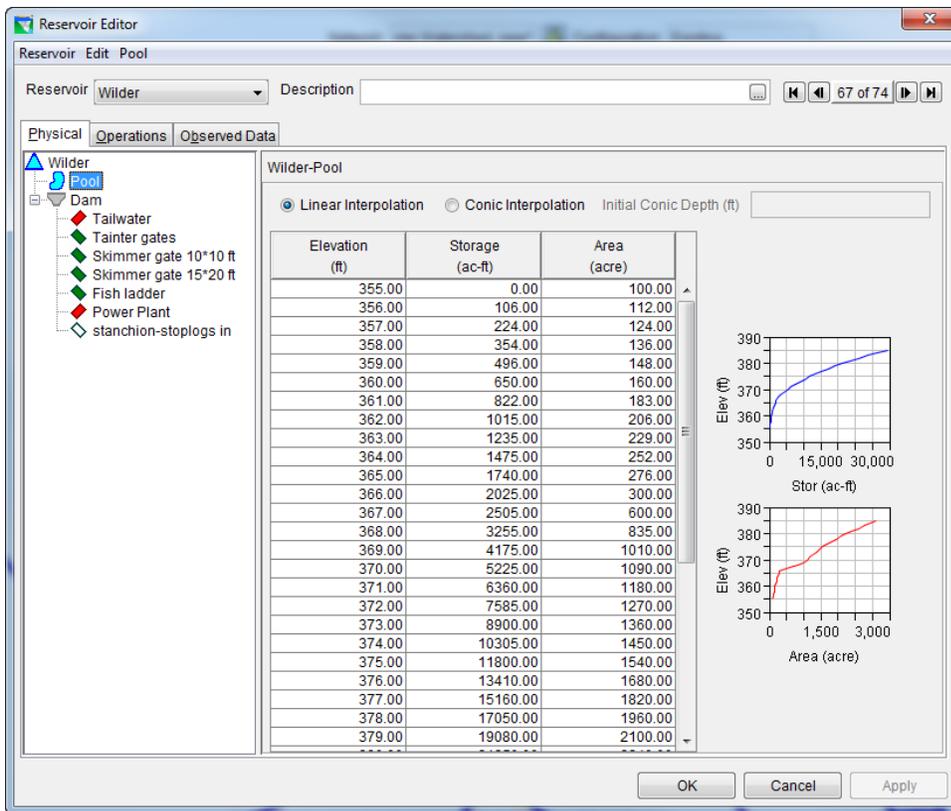


Figure 3: Reservoir Editor: Physical Tab -- Pool

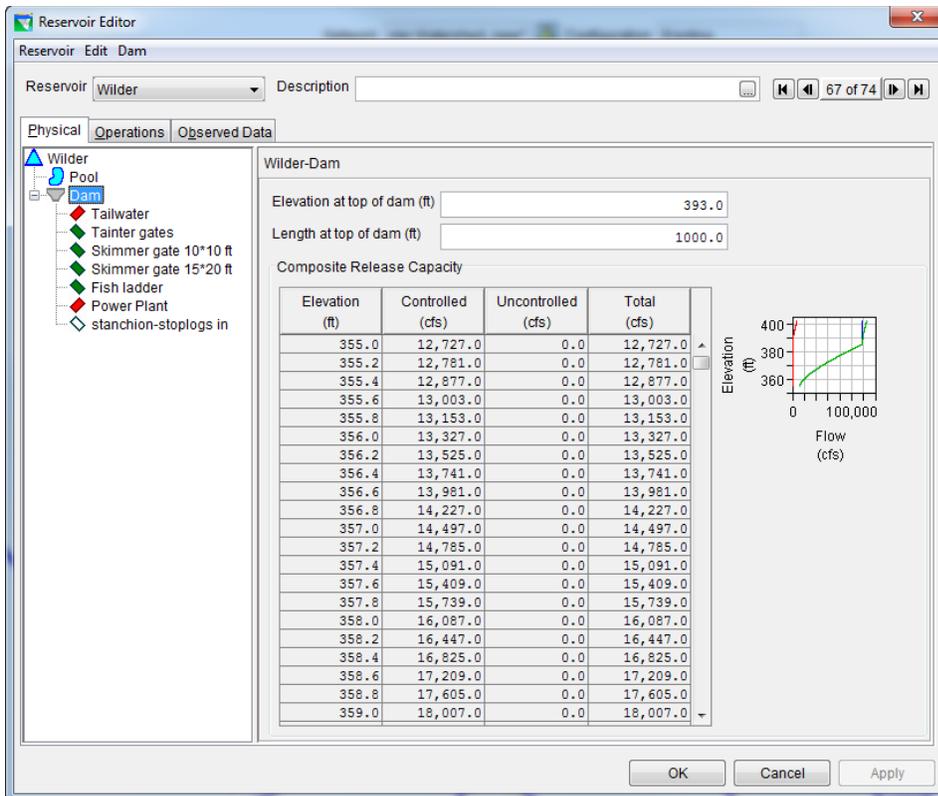


Figure 4: Reservoir Editor: Physical Tab -- Dam

### III. Operations

#### A. Operation Set

Zones are used to define the operational storage in the reservoir to determine the reservoir release through analysis of the rules contained within each zone. Figure 5 shows the definition of Wilder’s “ExistingOps” operational zones, which consist of zones of Flood Control (393 ft), FERC Max Pool (385 ft), Conservation (384.5 ft), Buffer (382 ft), and Inactive zone (380 ft)<sup>1</sup>.

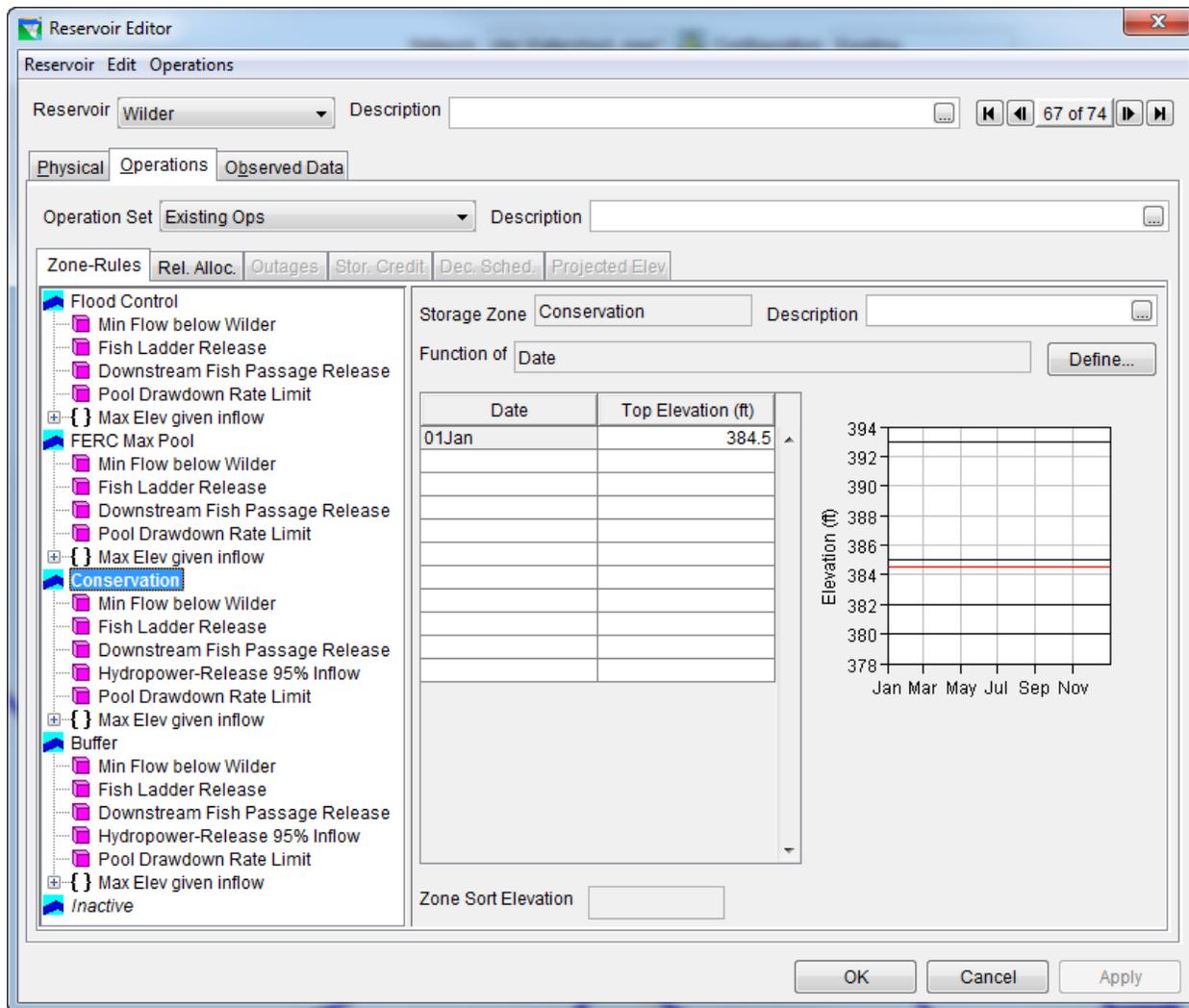


Figure 5: Reservoir Editor: Operations Tab –Existing Ops OpSet – Guide Curve

## B. Rule Illustrations

Figure 6 shows a set of operational rules specified for each zone that reflects the operation set named Existing Ops<sup>113</sup>.

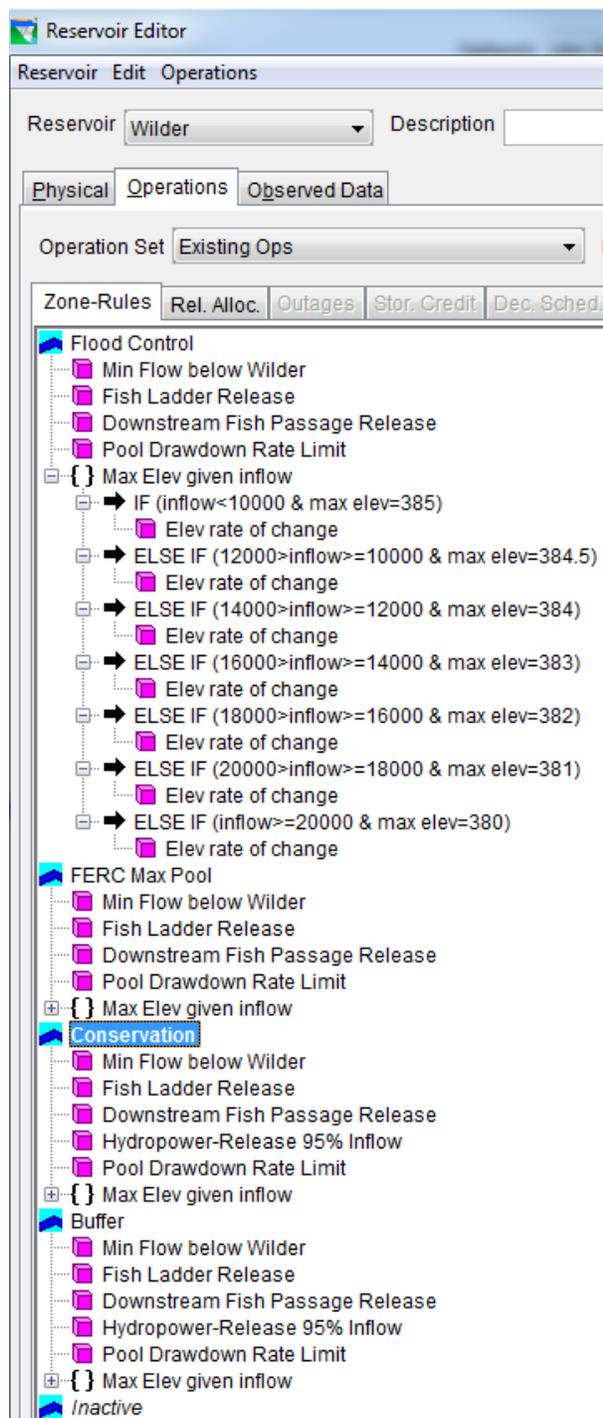


Figure 6: Reservoir Editor: Operations Tab – Existing Ops OpSet – Zones and Rules

<sup>113</sup> TransCanada. Connecticut River Operational Constraints. 2012.

Figure 7 shows a sequential release allocation approach specified for available outlets along Bellows Falls Dam. The available outlets are given an order of priority for release. The power plant gets the release first until it reaches release capacity. The Tainter gates get the remainder of the release until they reach capacity. Then the flow passes through skimmer gate 15\*20 and 10\*10. After the capacity through the skimmer gates is reached, the remainder of the release goes through the Fish ladder gate.

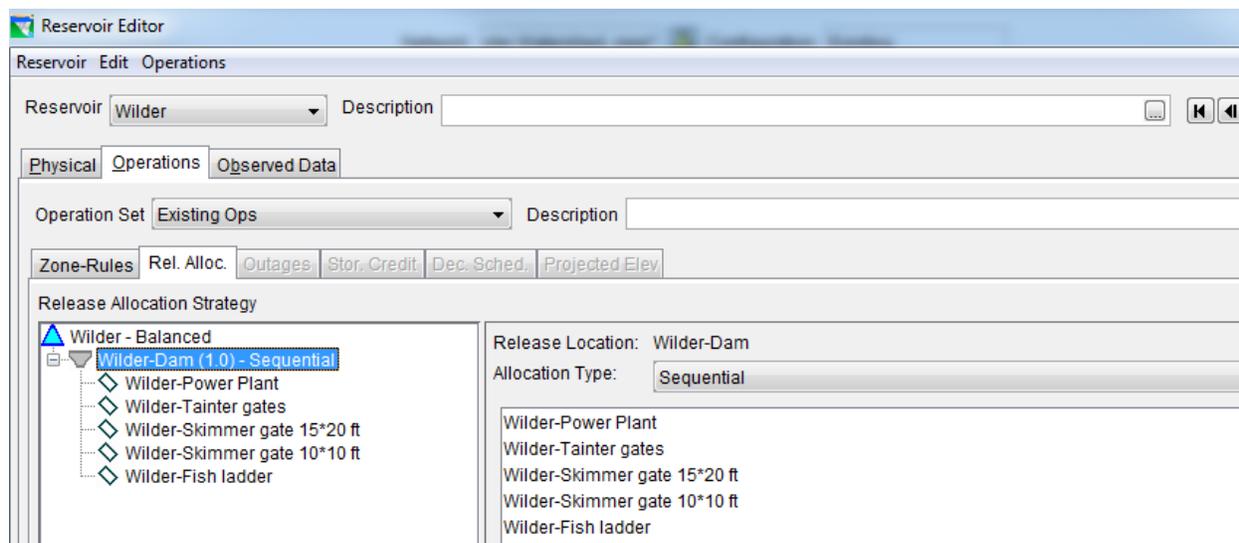


Figure 7: Reservoir Editor: Operations Tab – Existing Ops OpSet – Release Allocation

## C. Rule Descriptions

### 1. Min Flow below Wilder

Figure 8 shows the content of “Min Flow below Wilder” rule. This rule shows a minimum release from dam as a function of Inflow.

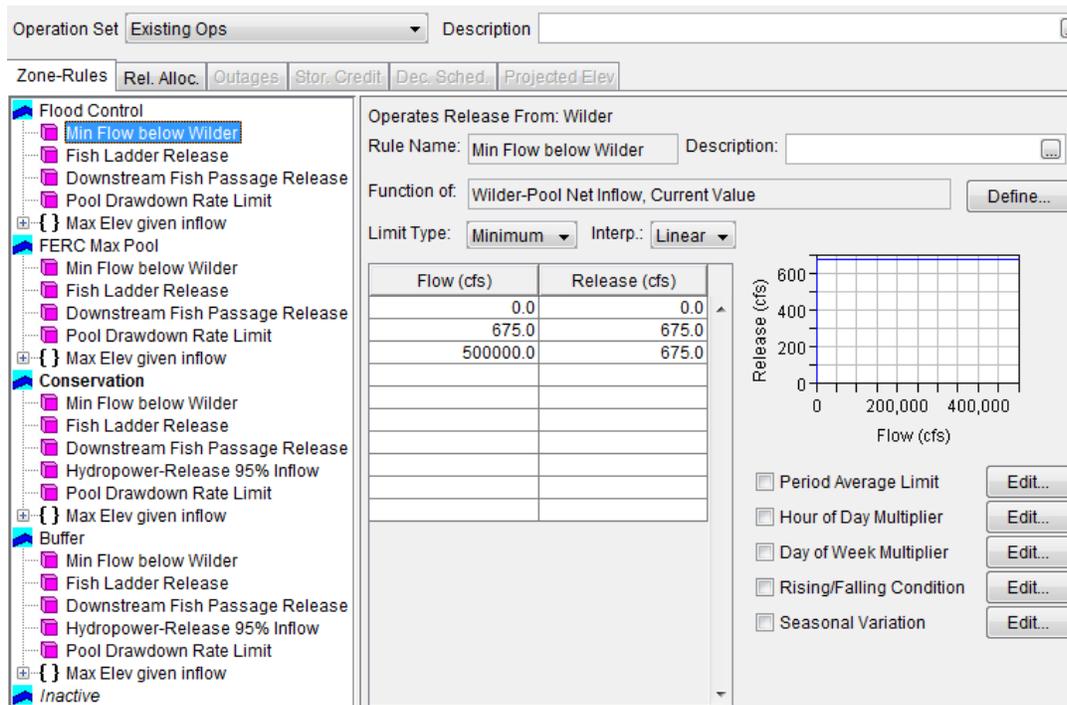


Figure 8: Reservoir Editor: Operations Tab – Existing Ops OpSet – Min Flow below Wilder

## 2. Fish Ladder Release

Figure 9 shows the content of “Fish Ladder Release” rule. This rule shows the specified release from Fish Ladder gate.

The screenshot displays the 'Fish Ladder Release' rule configuration in the Reservoir Editor. The 'Operation Set' is 'Existing Ops'. The rule name is 'Fish Ladder Release' and the description is 'Release 25 cfs from May 15-Jul'. The function is set to 'Date' and the limit type is 'Specified' with a step interpolation. A table shows release rates of 0.0 cfs for most months and 25.0 cfs for May, July, and September. A graph on the right visualizes these release rates over a year. On the right side, there are several unchecked options: 'Period Average Limit', 'Hour of Day Multiplier', 'Day of Week Multiplier', 'Rising/Falling Condition', and 'Seasonal Variation', each with an 'Edit...' button.

| Date  | Release (cfs) |
|-------|---------------|
| 01Jan | 0.0           |
| 15May | 25.0          |
| 15Jul | 0.0           |
| 15Sep | 25.0          |
| 15Nov | 0.0           |

Figure 9: Reservoir Editor: Operations Tab – Existing Ops OpSet – Fish Ladder Release

### 3. Downstream Fish Passage Release

Figure 10 shows the content of “Downstream Fish Passage Release” rule. This rule shows the specified release from skimmer gate 15\*20 ft.

The screenshot displays the 'Operations Tab' in the Reservoir Editor. The 'Existing Ops' set is selected, and the 'Downstream Fish Passage Release' rule is highlighted in the tree view. The main configuration area shows the rule's details:

- Operates Release From:** Wilder-Skimmer gate 15\*20 ft
- Rule Name:** im Fish Passage Release
- Description:** Release 512 cfs for downstream
- Function of:** Date
- Limit Type:** Specified
- Interp.:** Step

A table lists the release schedule:

| Date  | Release (cfs) |
|-------|---------------|
| 01Jan | 0.0           |
| 01Apr | 512.0         |
| 15Jun | 0.0           |

To the right of the table is a graph showing 'Release (cfs)' on the y-axis (0 to 600) and months on the x-axis (Jan to Nov). The graph shows a rectangular pulse of 512 cfs from April 1st to June 15th.

Additional options on the right include:

- Period Average Limit
- Hour of Day Multiplier
- Day of Week Multiplier
- Rising/Falling Condition
- Seasonal Variation

Figure 10: Reservoir Editor: Operations Tab – Existing Ops OpSet – Downstream Fish Passage Release

#### 4. Pool Drawdown Rate Limit

Figure 11 shows the content of “Pool Drawdown Rate Limit” rule. This rule shows the decreasing elevation rate of change rule.

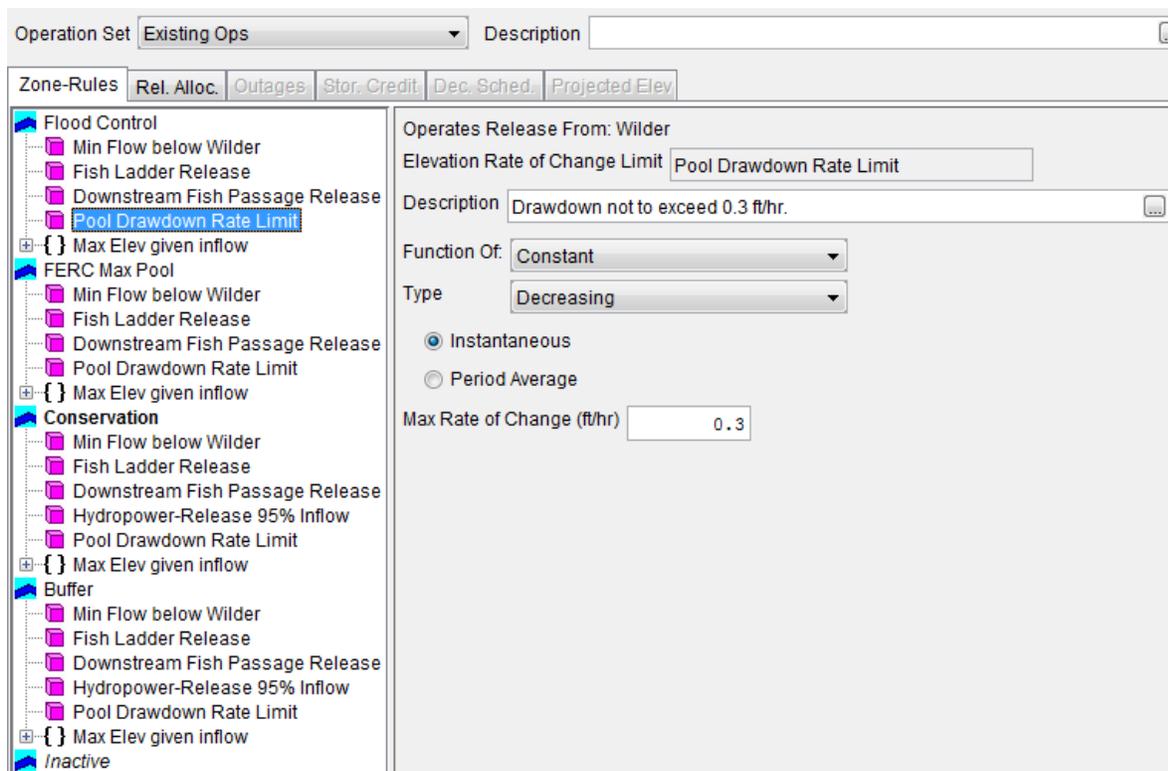


Figure 11: Reservoir Editor: Operations Tab – Existing Ops OpSet – Pool Drawdown Rate Limit

### 5. Hydropower-Release 95% Inflow

Figure 12 shows the content of “Hydropower-Release 95% Inflow” rule. This rule passes 95% of Inflow through power plant. Wilder was modeled as run-of-river even though it has daily peaking operations because the model is a daily time step model.

The screenshot shows the 'Operations Tab' in the Reservoir Editor. The 'Operation Set' is 'Existing Ops'. The 'Zone-Rules' are categorized into Flood Control, FERC Max Pool, Conservation, Buffer, and Inactive. The 'Hydropower-Release 95% Inflow' rule is selected under the Conservation category.

The rule configuration is as follows:

- Operates Release From: Wilder-Power Plant
- Rule Name: lower-Release 95% Inflow
- Function of: Wilder-Pool Net Inflow, Current Value
- Limit Type: Minimum
- Interp.: Linear

| Flow (cfs) | Release (cfs) |
|------------|---------------|
| 0.0        | 0.0           |
| 100000.0   | 95000.0       |

A graph shows the relationship between Flow (cfs) on the x-axis and Release (cfs) on the y-axis. The x-axis ranges from 0 to 100,000, and the y-axis ranges from 0 to 100,000. A blue line starts at (0,0) and goes to (100,000,95,000), representing a 95% release rate.

Additional options on the right include:

- Period Average Limit
- Hour of Day Multiplier
- Day of Week Multiplier
- Rising/Falling Condition
- Seasonal Variation

Figure 12: Reservoir Editor: Operations Tab – Existing Ops OpSet – Hydropower-Release 95% Inflow

### 6. Max Elev given Inflow

Figure 13 shows the content of “Max Elev given Inflow” rule. For each combination of Inflow and maximum pool elevation shown in the below picture the maximum elevation rate of change equals zero.

The screenshot displays the 'Operations Tab' in the Reservoir Editor for the 'Existing Ops' OpSet. The left-hand tree view shows the hierarchy of rules under 'Flood Control', with 'Max Elev given inflow' selected. The main configuration area shows the rule's name and a table of conditions. The bottom section provides a detailed view of the selected rule's parameters.

| Type    | Name                                 | Description |
|---------|--------------------------------------|-------------|
| IF      | inflow<10000 & max elev=385          |             |
| ELSE IF | 12000>inflow>=10000 & max elev=384.5 |             |
| ELSE IF | 14000>inflow>=12000 & max elev=384   |             |
| ELSE IF | 16000>inflow>=14000 & max elev=383   |             |
| ELSE IF | 18000>inflow>=16000 & max elev=382   |             |
| ELSE IF | 20000>inflow>=18000 & max elev=381   |             |
| ELSE IF | inflow>=20000 & max elev=380         |             |

**Rule Configuration Details:**

- Operates Release From: Wilder
- Elevation Rate of Change Limit: Elev rate of change
- Description: [Empty]
- Function Of: Constant
- Type: Increasing
- Instantaneous:  (Selected)
- Period Average:
- Max Rate of Change (ft/hr): 0.0

Figure 13: Reservoir Editor: Operations Tab – Existing Ops OpSet – Max Elev given Inflow

# Woronoco

## I. Overview

Woronoco dam is located two miles below Russell, MA on the Westfield River. It is owned and operated by Swift River Hydro Operations Company and is used for hydropower generation.

Figure 1 shows the location of Woronoco Dam as it is represented in the HEC-ResSim model. Figure 2 shows a photo of Woronoco Dam.

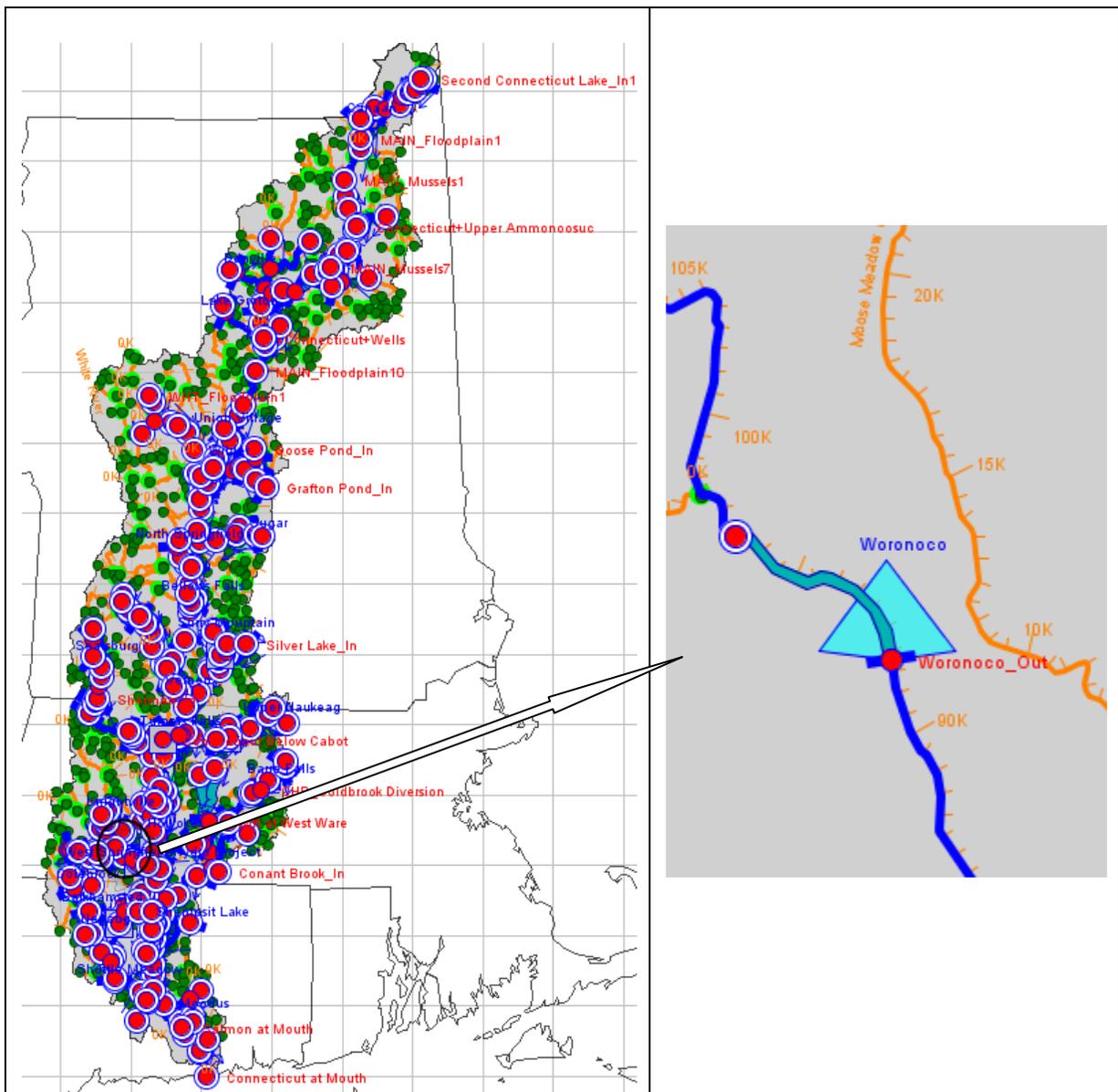


Figure 1: HEC-ResSim Map Display Showing Location of Woronoco Dam



Figure 2: Photo of Woronoco dam

## II. Physical Characteristics

The physical characteristics of the reservoir are separated between the Pool and the Dam in the HEC-ResSim model. The elevation-storage-area defines the pool as shown in Figure 3<sup>114</sup>. The dam consists of two types of outlets: (1) uncontrolled outlet and (3) power plant as shown in Figure 4<sup>115</sup>. The capacity of the power plant was made to be the maximum release specified in the NID database so that the dam would modeled completely as run-of-river with some actual physical information.

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<sup>114</sup> National Inventory of Dams database (NID)

<sup>115</sup> <http://www.swiftriverhydro.com/Woronoco%20Hydro.htm>



### III. Operations

#### A. Operation Set

Zones are used to define the operational storage in the reservoir to determine the reservoir release through analysis of the rules contained within each zone. Figure 5 shows the definition of Woronoco’s “Guide Curve” operational zones, which consist of Top of Dam (25 ft), Conservation (24.9 ft), and Inactive zone (15 ft)<sup>1</sup>.

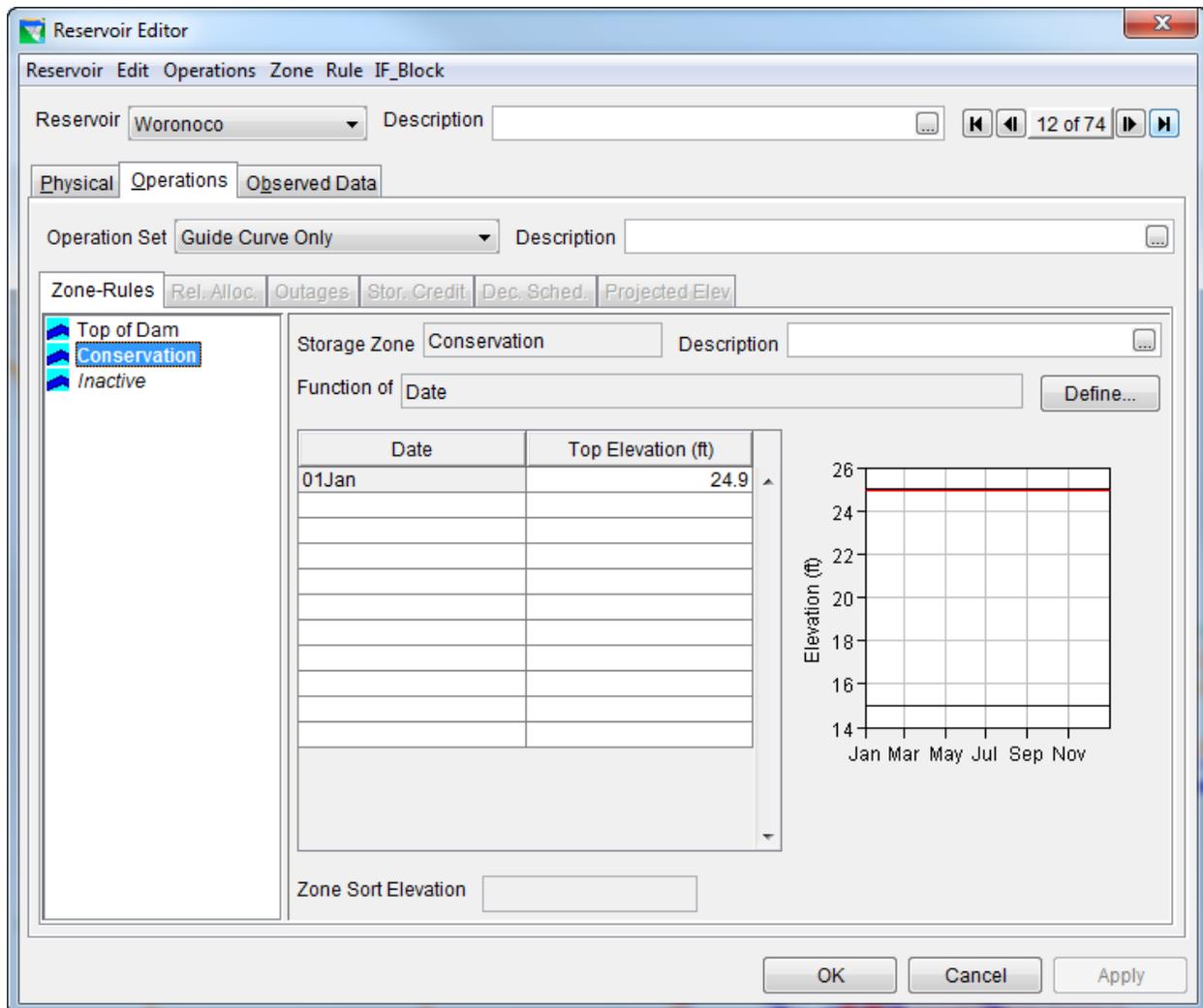


Figure 5: Reservoir Editor: Operations Tab –Guide Curve OpSet – Guide Curve

#### B. Rule Illustrations

The operation set for Woronoco has no rules of operation making it a flow through reservoir. The pool elevation will remain at the top of conservation unless the inflow exceeds the total release capacity. This was modeled this way because no real operation information was found.

